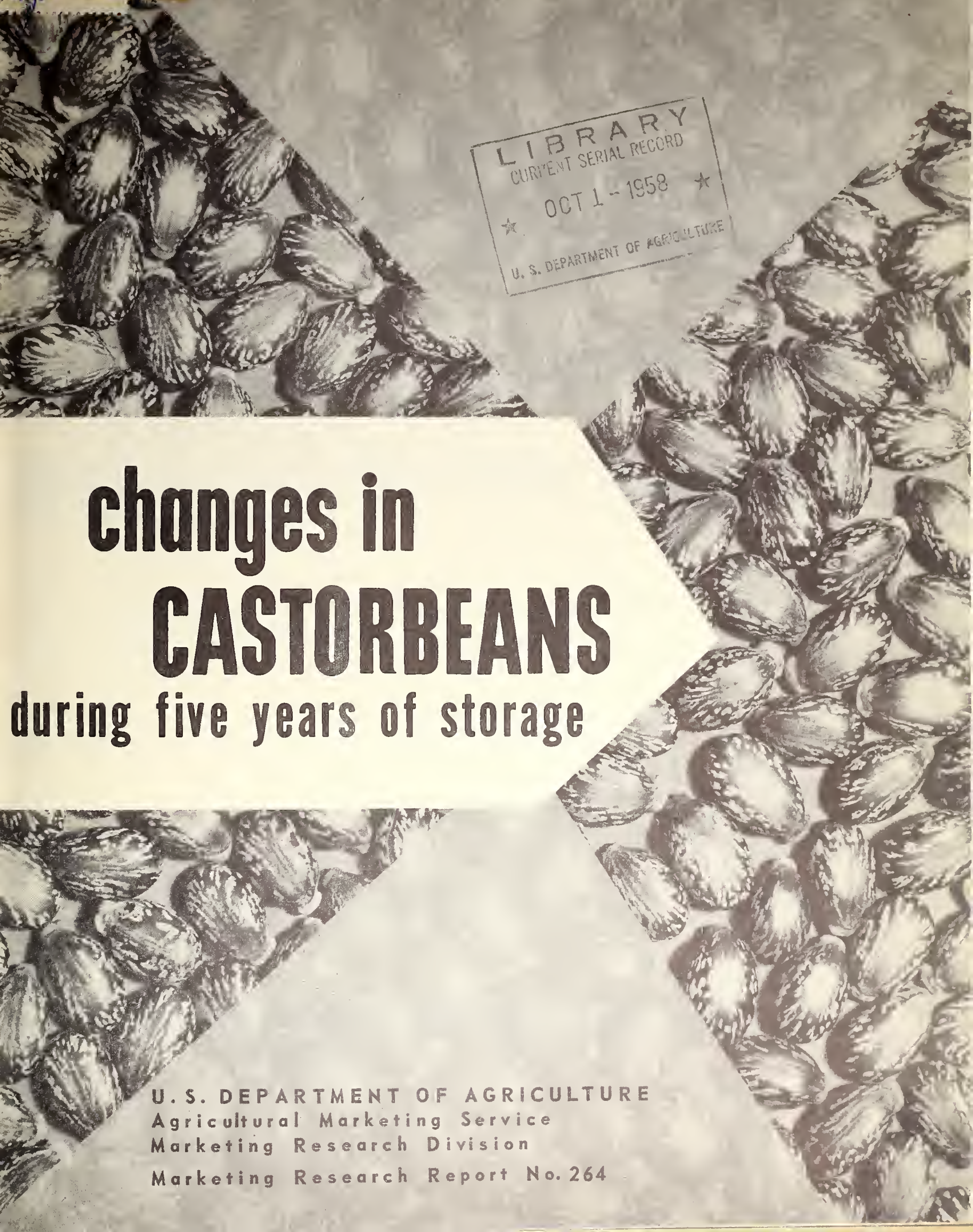

changes in CASTORBEANS during five years of storage

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division

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ACKNOWLEDGMENTS

The samples of castorbeans used for chemical analysis were drawn from stored lots made available for research purposes by the Commodity Credit Corporation. The sampling was done by Walter A. Davis, marketing specialist, formerly with the Commodity Stabilization Service, and B. C. Langley, superintendent, Texas Agricultural Experiment Substation (No. 20), Stephenville, Tex.

The chemical analysis data used in the report were obtained from laboratory tests of castorbean samples submitted to the Standardization and Testing Branch, Grain Division, Agricultural Marketing Service, and the George W. Gooch Laboratories, Los Angeles, Calif.

A preliminary report of findings obtained for the first 2 years of the castorbean study, by George W. Kromer, was published in 1955. It is Marketing Research Report No. 106, entitled "Economic Factors in Marketing Farmers' Castorbeans."

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SUMMARY

In this castorbean storage study covering a period of 5 years, the findings show that: (1) Castorbeans store well under normal conditions with only small economic losses. The oil from the beans stored 2 years still met National Stockpile Specifications for No. 1 oil; (2) quality of oil from stored castorbeans decreased over time, becoming grade No. 3 with respect to color in the third year; (3) oil from beans in storage up to 5 years still met stockpile specifications for No. 3 oil in all respects; (4) cracked and broken beans yield more oil per bushel than whole sound beans but the quality is somewhat lower and goes out of condition more rapidly than that from whole beans; (5) average oil content of both types of samples of castorbeans tends to decrease somewhat during storage; (6) stored castorbeans tend to absorb moisture in cold months and lose moisture in hot months, although the average moisture content declines over time.

For the first 2 years' storage the oil from 100-percent whole beans, 100-percent cracked and broken beans, and representative samples or field-run beans met the National Stockpile Specifications for No. 1 oil. During the third year, the oil from all 3 types of samples averaged Gardner color No. 4, thus exceeding the color maximum of "3" permitted by stockpile specifications for No. 1 oil. During the remaining 3 years' storage, the oil from whole beans and field-run beans, except for color, continued to meet stockpile specifications for No. 1 oil. In none of these 3 years did oil color of individual observations exceed "8" or average more than "6" for these 2 types of samples. During the fourth and fifth years of storage the free fatty acid content of the oil from cracked and broken beans, however, averaged 2.4 percent and 3.4 percent, respectively, thus exceeding the maximum limit of 1.5 percent permitted for No. 1 oil, but still well within the tolerance for No. 3 oil.

During the 5 years' storage, the oil from the whole beans, cracked and broken beans, and field-run beans had an average specific gravity of 0.962, an average iodine number of 87, and contained an average of 0.53 percent unsaponifiable matter. With respect to each of these 3 oil-quality factors, the oil from all 3 types of beans met stockpile specifications for No. 1 oil throughout the storage experiment.

The average oil content of the beans included in this study was 55 percent (clean moisture-free basis). The cracked and broken beans yielded 9.3 percent more oil than did whole beans for the first 2 years and an average of 8.7 percent more oil for the 5 years' storage period. The 9.3 percent (or 5.0 percentage points) difference in oil-yield per ton converted to pounds and then to market value at 23 cents per pound of No. 1 oil would be worth $21.85 per ton. The 8.7 percent (or 4.6 percentage points) difference in oil-yield per ton of whole beans, converted to market value at 22 cents per pound of No. 3 technical grade oil, would be worth $19.37 per ton, assuming a 95 percent recovery rate.

The average oil content of castorbeans tends to decrease during storage. The average loss of oil in whole beans, cracked and broken beans, and field-run beans during the storage period was 2.2, 2.7, and 2.4 percent, respectively. These percentages of No. 3 grade oil, converted to market value at 22 cents per pound would represent economic losses of $5.23, $6.97, and $5.77. respectively, per ton of beans stored 5 years.

The moisture content of the beans at the beginning of the storage period was 6.4 percent for whole beans, 5.7 percent for cracked and broken beans, and 6.2 percent for the field-run beans. For the fifth year of storage, however, the average moisture content of these beans was 5.6, 5.1, and 5.6 percent, respectively. Thus, the average loss in moisture in these beans during storage was 12, 11, and 10 percent, respectively. The average moisture content of cracked and broken beans was 9.0 percent less than that for whole beans. Both whole beans and cracked and broken beans absorb moisture during cold months and lose moisture during hot ones, but their rates of absorption differ. For example, the average moisture content for whole beans was 19.6 percent higher in winter than in summer, whereas that for cracked and broken beans was only 17.3 percent higher. As cracked and broken beans have lost all or part of their seed coat and thus are more oily, they are not likely to absorb as much moisture as whole beans.

CHANGES IN CASTORBEANS DURING FIVE YEARS OF STORAGE

By Harland N. Doughty, agricultural economist
Marketing Research Division
Agricultural Marketing Service

BACKGROUND AND PURPOSE OF THE STUDY

The purpose of this castorbean storage study is to determine how long the beans can be stored and maintain their quality. Economic considerations are included of the differences in characteristics and relationships among whole beans, cracked and broken beans, and field-run beans from storage with respect to the quality and quantity of their extracted oil.

This study is a part of a broad program of research aimed at improving market efficiency and expanding markets for farm products.

Castor oil and its derivatives constitute a source of raw material used in the manufacture of many items which have important industrial, military, and everyday consumer uses. Sulphonated castor oil is used in textile printing and in the finishing of cotton, linen, silk, and leather. Dehydrated castor oil provides a quick-drying base for paints, enamels, and varnishes used in the protective coating industry. Sebacic acid, produced by high-temperature fusion of castor oil and caustic soda, is one of the materials used in making plastics, nylon, and synthetic lubricants for jet aircraft. Castor oil has medicinal use as a purgative, whereas hydrogenated castor oil is sulphonated for use in the preparation of ointments. Castor oil, freely soluble in alcohol, is used in the manufacture of hair lotions and aromatic perfumes.

The United States is a major user of castor oil and the principal importer of castor oil and beans. During the last 10 years, the annual disappearance of castor oil through manufacturing processes in this country has ranged from 116 million pounds for 1947 to 182 million for 1952 (table 1). During the same period this country's annual imports of castor oil and beans have represented a share of the total world trade ranging from about 46 percent for 1955 to about 84 percent for 1949 (table 2). Despite the high percentage figure for 1949, U. S. imports that year were 156,000 short tons compared to 198,000 tons in 1953.

It is estimated that 135 million pounds of castor oil were used in this country's various manufacturing processes in 1957, whereas only about 9.5 million pounds were produced from beans grown domestically. Thus, it is estimated that U. S. industry met about 93 percent of its needs from imported beans and oil that year.

Table 1.--Castor oil: Supply, disposition, and price, U. S., 1947-57

Year	Supply					Disposition			
	Production from--								
	Domestic material 1/	Imported material	Imports	Stocks Jan. 1	Total	Exports	Computed disappearance	Factory consumption	Price No. 1 2/
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Cents
1947		117	7	19	143	4	116	91	29.1
1948		136	2	24	162	2	128	107	22.7
1949		128	11	32	171	3	130	87	18.1
1950		128	47	38	213	2	181	120	20.4
1951	5	74	89	30	198	1	174	108	33.6
1952	8	66	112	23	209	1	182	81	28.9
1953	10	56	127	26	219	1	169	85	22.6
1954	7	55	57	50	169	1	138	79	17.2
1955	1	49	95	30	175	1	136	100	15.9
1956	3	23	89	39	154	3	121	93	19.2
1957 3/	10	16	121	28	175	3	139	95	23.1
1958 3/				33					

1/ Estimated.
2/ Tanks, f.o.b. New Jersey mills.
3/ Preliminary.

Totals computed from unrounded numbers.

Source: Fats and Oils Situation No. 189. Agr. Mktg. Serv., U. S. Dept. Agr., March 1958. Table No. 8, p. 23.

Table 2.--Castorbeans: World production, exports, U. S. imports, and prices, 1947-57

Year	World			U. S. imports			Price per ton of beans at Brazilian ports
	Production		Exports				
	Total	Excluding U. S.	Beans and oil in terms of beans	Beans	Bean equivalent of oil 2/	Total	
	1,000 short tons	1,000 short tons	1,000 short tons	1,000 short tons	1,000 short tons	1,000 short tons	Dollars
1947	464	464	272	138	7	145	216.10
1948	547	547	256	151	3	154	147.16
1949	504	504	184	145	11	156	108.30
1950	541	541	289	132	52	184	141.43
1951	521	510	267	75	99	174	260.02
1952	511	499	289	70	124	194	196.38
1953	518	492	302	57	141	198	145.60
1954	497	492	260	55	63	118	102.95
1955	486	485	326	44	106	150	114.09
1956	484	482	258	21	99	120	153.02
1957 1/	536	526	280	17	127	144	164.45

1/ Preliminary.
2/ Assuming 45 percent oil content.

Source: Fats and Oils Situation, No. 189, Agr. Mktg. Serv., U. S. Dept. Agr., March 1958. Table No. 7, p. 23.

Prior to 1950, very few castorbeans were grown commercially in the United States. In that year the Munitions Board classified castor oil as one of 6 strategic oils and in the following year the Department of Agriculture initiated a domestic castorbean production and procurement program which was continued through the 1954-55 season. There was no program for the 1955 or subsequent crop.

This program, conducted by the Commodity Credit Corporation, had three purposes: (1) To increase the supply of castor oil for industrial use in connection with certain military and essential civilian requirements; (2) to provide additional quantities of oil for strategic stockpile; and (3) to assist growers in gaining experience in producing castorbeans so that in case of emergency domestic supplies could be expanded rapidly.

The program was made available to growers in those areas within several Southwestern States designated by the CCC and for which adapted varieties of planting seed were available. To encourage castorbean production, the Government guaranteed farmers a minimum price up to 10 cents per pound for the castorbeans they produced. Growers participating in the program entered into contracts with the CCC, with private companies, or with cooperative associations.

Under the guaranteed price incentive, domestic acreages of castorbeans harvested increased from about 63,000 in 1951 to about 125,000 in 1953 (table 3). Moreover, during the first 3 years of the program, domestic castorbean production increased sharply from about 21 million pounds in 1951 to over 51 million in 1953. For the following year, however, when the guaranteed price was reduced to 6 cents per pound, castorbean acreage declined to less than 27,000 and production decreased to somewhat less than 11 million pounds.

During the next 2 years after the program had been concluded, this country's castorbean production declined still further, reaching a low of less than 5 million pounds in 1956. The rather small domestic output for 1955 and 1956 is explained in part by uncertain prices and difficulties encountered in cultivating and harvesting the beans.

In 1957, domestic growers harvested approximately 15,500 acres which yielded about 21 million pounds of beans, according to trade estimates. This sharp increase in castorbean production represents to a great extent a response to more favorable prices and to the availability of improved varieties of castorbeans adapted to mechanical production and more efficient machines with which to harvest and hull them.

In view of the importance of castor oil in manufacturing processes and of our dependance on foreign sources for most of our supply of castor oil and beans, it is understandable that there should be considerable interest in domestic castorbean production, storage, and marketing. If an emergency developed, information concerning these aspects of castorbeans would be especially important, and as domestic production expands, such information would be useful

Table 3.--Castorbeans: Estimated acreage, yield and production, by States, 1951-57

State	1951	1952	1953	1954	1955	1956	1957
	Harvested acreage						
	1,000 acres	1,000 acres	1,000 acres	1,000 acres	1,000 acres	1,000 acres	1,000 acres
California (irrigated) ..	15.1	1.3	3.7	2.3	0.7	0.8	6.5
Arizona (irrigated	3.8	.5	2.6	.7	2.6	1.1	3.8
New Mexico (irrigated) ..	---	---	1.8	3.7	---	---	1.6
Texas 1/	19.5	72.2	79.6	10.0	---	.5	2.9
Oklahoma 2/	24.3	23.6	35.5	7.4	1.3	1.5	.1
Arkansas	3/	4/	1.3	1.0	.2	.2	.1
Tennessee	---	---	---	---	.2	.5	.2
Mississippi	---	---	---	---	.1	.2	.4
Missouri	---	---	---	1.5	---	---	---
United States	62.7	97.6	124.5	26.6	5.1	4.8	15.5
	Production						
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
California (irrigated) ..	11.4	1.6	5.3	2.9	1.1	1.7	11.9
Arizona (irrigated)	3.4	.4	3.5	.7	2.0	1.2	5.2
New Mexico (irrigated) ..	---	---	1.2	2.7	---	---	1.8
Texas 1/	2.6	17.5	30.2	2.4	---	.5	1.8
Oklahoma 2/	3.3	4.9	10.6	1.4	.2	.2	5/
Arkansas	5/	.1	.4	.3	.1	5/	5/
Tennessee	---	---	---	---	5/	.1	.1
Mississippi	---	---	---	---	5/	.1	.3
Missouri	---	---	---	.5	---	---	---
United States	20.8	24.6	51.3	10.8	3.4	3.8	21.1
	Yield per acre						
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
California (irrigated) ..	756	1,218	1,442	1,275	1,614	1,988	1,828
Arizona (irrigated)	905	982	1,354	912	750	1,048	1,342
New Mexico (irrigated) ..	---	---	665	725	---	---	1,151
Texas 1/	135	242	380	243	---	966	620
Oklahoma 2/	137	2,208	299	186	150	150	300
Arkansas	428	4/	288	307	300	170	300
Tennessee	---	---	---	---	200	252	667
Mississippi	---	---	---	---	291	430	857
Missouri	---	---	---	323	---	---	---
United States	332	252	412	408	665	778	1,361

1/ 1951-54 mostly dryland; since then largely irrigated. 2/ Mostly dryland but does include some irrigated areas. 3/ Less than 50 acres. 4/ No data available. 5/ Less than 50,000 pounds.

Totals computed from unrounded numbers.

Estimates for 1951-54 based on data collected by CCC during the 4-year domestic castorbean production and procurement program. Estimates for 1955-57 were provided by The Baker Castor Oil Company.

Source: Fats and Oils Situation, No. 188, Agr. Mktg. Serv., U. S. Dept. Agr., Jan. 1958. Table No. 13, p. 25.

The castorbean production and procurement program, which made available a great amount of data on grade factors and related information, provided an excellent opportunity for an economic analysis of these data. An economic study 1/ initiated in 1952 was conducted to determine: (1) What effect climate, irrigation, variety, moisture content, and foreign material may have on outturn value of castorbeans; (2) whether the practice of docking growers for cracked and broken beans was justified; (3) whether the oil from cracked and broken beans and that from whole sound beans differ in quality; (4) how long castorbeans can be stored and maintain their quality; and (5) what effect storage may have on castorbeans as related to outturn of products.

In that comprehensive report, the section relating to castorbean storage was based on analysis of data collected during the first 24 months of the storage experiment. The beans remained in storage, however, and additional data were obtained during the following 3 years.

The current study is a continuation of that part of the previous study concerned with castorbean storage and in light of additional data, relates to three central questions:

(1) How long may castorbeans be stored and maintain their quality?
(2) What are the differences in characteristics and relationships among whole sound castorbeans, cracked and broken beans, and field-run beans from storage with respect to the quantity and quality of their extracted oil?
(3) What economic implications can be drawn from these storage experiments?

SAMPLES AND DATA USED

In October 1952, CCC made available for research purposes an experimental lot of 90,000 pounds of Connor variety castorbeans from the 1952 crop. The beans had been grown in the dryland areas near Whitesboro, Texas. They were hulled at the receiving center there and stored in bulk in a quonset building. The beans remained in storage at Whitesboro until July 1955, then were moved to Stephenville, Texas, for continued storage under similar conditions.

Beginning in February 1953, samples from beans in storage were drawn at intervals from 3 types--(1) 100-percent whole beans, (2) 100-percent cracked and broken beans, and (3) representative mixtures of whole and cracked and broken beans or field-run beans. During the first $2\frac{3}{4}$ years, samples were drawn twice a month whenever the outside temperature exceeded 80 degrees, and at least once a month. For the remaining storage period, however, samples were drawn only once each quarter by seasons. A total of 32 samples for each type was drawn during the first 2 years' storage, whereas 22 samples were drawn during the remaining 3 years.

1/ Kromer, George W. Economic Factors in Marketing Farmers' Castorbeans. Mktg. Res. Rpt. No. 106. U. S. Dept. Agr., Washington, D. C. 46 pp. 1955.

The 3 types of samples were used in order to determine (1) the relationship between whole beans and cracked and broken beans, and (2) the extent to which whole beans and cracked and broken beans differed from representative samples containing both. The official test methods of the American Oil Chemists' Society were used to determine the moisture and oil content for each 300-gram sample and the laboratory-extracted oil was chemically analyzed for specific gravity, color, neutralization number, free fatty acids (as oleic), iodine number, and unsaponifiable matter to determine quality.

EXPERIMENTS ON STORAGE OF CASTORBEANS

Growers do not generally store castorbeans on the farm, though they do occasionally store them in the hulls temporarily for the purpose of drying. Processors may have to store the hulled beans for a short time since they usually receive most of the domestic crop within the relatively short harvesting season which may extend over a period of 6 weeks to 2 months, whereas they process beans throughout the year.

Until the results of Marketing Research Report No. 106 were published, there had been practically no information available concerning storage characteristics of castorbeans. That report indicated certain changes in physical and chemical characteristics that take place in beans during storage and which should be taken into account for more efficient marketing.

The objective of the current study is to appraise those findings in light of additional data and to expand the economic aspects of castorbean storage and marketing with respect to changes in quality and quantity of the oil from stored beans.

Oil Content of Castorbeans Through 5 Years of Storage

The results of this study indicate that average oil content of cracked and broken castorbeans is greater than that of whole sound beans (fig. 1). 2/ During the first year of storage the average oil content (clean, moisture-free basis) of whole beans was 54.0 percent as compared to 58.7 percent for cracked and broken beans. This represents 8.7 percent more oil in cracked and broken beans than in whole beans. Cracked and broken beans yield more oil than whole sound beans, because some of the seedcoat, which contains only about 2 percent of oil, is lost when beans are broken.

For the first 2 years of storage the average oil content of the whole beans remained at 54.0 percent while that of the cracked and broken beans increased from 58.7 to 59.0 percent though this change is relatively small. The cracked and broken beans then contained an average of 9.3 percent more oil than the whole beans. This differential advantage in average oil content for cracked

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2/ The data presented in this graph and in succeeding graphs represent quarterly averages unless otherwise indicated.

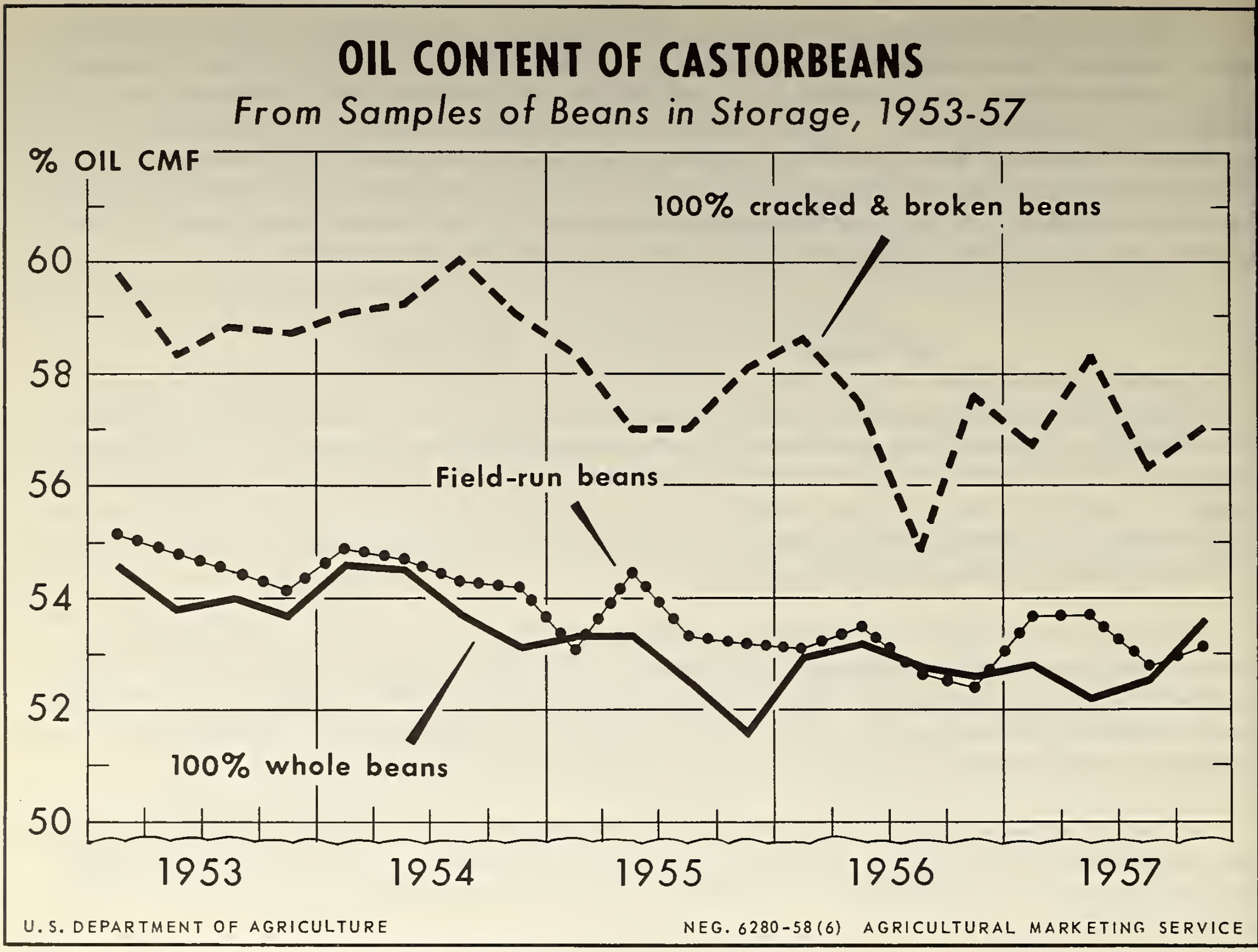

Figure 1

and broken beans was maintained during the third year of storage. During the next 2 years, however, this advantage in average oil content decreased so that for the 5-year storage period the average oil content of the cracked and broken beans was 8.7 percent greater than that of the whole beans. 3/ This substantiates a conclusion of Marketing Research Report No. 106 that no jusfification was found for docking farmers' castorbeans for containing cracked and broken beans. (The practice of docking lots of castorbeans for cracked and broken beans was discontinued in the spring of 1956.)

The direct relationship between oil content and cracked and broken beans is indicated further by the fact that field-run castorbeans containing an average amount of cracked and broken beans yielded more oil than the 100-percent whole beans though the difference was small. For example, during the first 3 years of storage the representative sample of field-run castorbeans, grown and stored under the same conditions as the two lots compared above and containing about 4.0 percent cracked and broken beans, had an average of 1.0 percent more

3/ On the "whole sample as received" basis, cracked and broken beans averaged 9.1 percent more oil than whole sound beans.

oil (clean, moisture-free basis) than the whole beans. During the next 2 years this advantage in oil content decreased so that for the 5 years' storage period the average oil content of the field-run beans was 0.8 percent greater than that of the whole beans.

Analysis of the castorbeans throughout 5 years of storage showed that while the oil content remained at about the same level throughout the first 2 years, it decreased somewhat during the remaining 3 years. Some of the variation noted probably was due to experimental error. The oil content of whole sound beans varied from 51.6 to 56.7 percent; cracked and broken beans from 54.8 to 62.0 percent; and field-run beans from 52.0 to 55.6 percent. During the 5 years' storage period the average oil content of these 3 lots of beans was 53.4, 58.0, and 53.8 percent, respectively. The average (mean) deviation was 0.75, 0.88, and 0.67 percent, respectively. 4/

For the purpose of comparison, the difference in oil-yield per year for the three types of samples during storage was converted to value in 2 ways: (1) By use of the average price of castor oil for the respective years, and (2) by use of the average price for the 5 years' storage period (table 4).

Based on average annual prices during the 5 years' storage period, the value of the oil-yield per ton of cracked and broken beans over that of whole beans ranged from $14.88 to $20.47. Moreover, the value of the oil-yield per ton of field-run beans over that of whole beans ranged from no difference to $2.53. Of course, not all of this variation in oil value was due to the difference in oil yield itself, since average annual prices of oil also varied.

Based on an average or constant price for the 5 years' storage period, the value of the oil-yield per ton of cracked and broken beans over that of whole beans ranged from $16.00 to $20.20. The average for the 5 years' storage period was $17.40. The value of the oil-yield per ton of field-run beans over that of whole beans ranged from no difference to $2.60, and averaged $1.40 (assuming a 95 percent recovery rate).

Chemical Analysis of Oil from Castorbeans in Storage

Chemical analyses of the oil from castorbeans stored up to 5 years were made to determine how long it would meet the requirements of the National Stockpile Purchase Specifications for castor oil. These specifications (September 23, 1952) outlined the following chemical and physical requirements for grades 1 and 3 castor oil, the test methods being those of the American Oil Chemists' Society (A.O.C.S) or the American Society for Testing Materials (A.S.T.M.) in effect at the time the contract was awarded:

4/ Average deviation is a measure of dispersion. It represents the sum of the absolute deviations of the items from the average, divided by the number of cases.

Table 4.--Analysis of variation in oil yield and value for three types of castorbean samples during 5 years' storage, 1953-57

Types of samples from storage	Oil content per ton: Percentage 1/	Oil content per ton: Quantity	Price per pound 2/	Oil recovered per ton: Quantity 3/	Oil recovered per ton: Value 4/	Oil recovered per ton: Value at constant price 4/, 5/
	Percent	Pounds	Cents	Pounds	Dollars	Dollars
1953:						
(1) Cracked and broken beans	58.7	1,174	0.23	1,115	256.45	223.00
(2) Field-run beans	54.6	1,092	.23	1,037	238.51	207.40
(3) Whole beans	54.0	1,080	.23	1,026	235.98	205.20
Difference between (1) and (3)	4.7	94	.23	89	20.47	17.80
Difference between (2) and (3)	.6	12	.23	11	2.53	2.20
1954:						
(1) Cracked and broken beans	59.3	1,186	.17	1,127	191.59	225.40
(2) Field-run beans	54.5	1,090	.17	1,036	176.12	207.20
(3) Whole beans	54.0	1,080	.17	1,026	174.42	205.20
Difference between (1) and (3)	5.3	106	.17	101	17.17	20.20
Difference between (2) and (3)	.5	10	.17	10	1.70	2.00
1955:						
(1) Cracked and broken beans	58.0	1,160	.16	1,102	176.32	220.40
(2) Field-run beans	53.8	1,076	.16	1,022	163.52	204.40
(3) Whole beans	53.1	1,062	.16	1,009	161.44	201.80
Difference between (1) and (3)	4.9	98	.16	93	14.88	18.60
Difference between (2) and (3)	.7	14	.16	13	2.08	2.60
1956:						
(1) Cracked and broken beans	57.1	1,142	.19	1,085	206.15	217.00
(2) Field-run beans	52.9	1,058	.19	1,005	190.95	201.00
(3) Whole beans	52.9	1,058	.19	1,005	190.95	201.00
Difference between (1) and (3)	4.2	84	.19	80	15.20	16.00
Difference between (2) and (3)	.0	0	.19	0	.00	.00
1957:						
(1) Cracked and broken beans	57.1	1,142	.23	1,085	249.55	217.00
(2) Field-run beans	53.3	1,066	.23	1,013	232.99	202.60
(3) Whole beans	52.8	1,056	.23	1,003	230.69	200.60
Difference between (1) and (3)	4.3	86	.23	82	18.86	16.40
Difference between (2) and (3)	.5	10	.23	10	2.30	2.40
1953-57 Average:						
(1) Cracked and broken beans	58.0	1,160	.20	1,102	220.40	220.40
(2) Field-run beans	53.8	1,076	.20	1,022	204.40	204.40
(3) Whole beans	53.4	1,068	.20	1,015	203.00	203.00
Difference between (1) and (3)	4.6	92	.20	87	17.40	17.40
Difference between (2) and (3)	.4	8	.20	7	1.40	1.40

1/ Clean moisture basis.
2/ Average annual price of castor oil per pound, tanks, f.o.b. New Jersey mills. New York Journal of Commerce.
3/ Based on 95 percent recovery rate, which screw-press mills average. Some hydraulic-solvent extraction processors are able to recover up to 99.5 percent of the oil in the beans.
4/ Value slightly higher for hydraulic-solvent extraction mills because less is left in the pomace.
5/ 1953-57 average price of castor oil per pound, tanks, f.o.b. New Jersey mills. New York Journal of Commerce.

Properties	Grade No. 1	Grade No. 3	A.O.C.S.	A.S.T.M.
Solubility at 20° C. (68° F.)	Complete	Complete	---	D960
Viscosity S.U.S.				
At 130° F. (54.4° C.)	500 to 550	450 to 550	---	D88
At 210° F. (98.9° C.) min.	95	90	---	D88
Acetyl value	140 to 150	140 to 150	Cd 4-40	---
Moisture and volatile				
At 212° F. (100° C.) max.	0.3	0.3	Ca 2c-25	---
Neutralization number or				
acid value, max.	3.0	12.0	---	D555
Color, Gardner 1933, max.	3	8	---	D555
Specific gravity, 60°/60° F.	.959 to .965	.957 to .965	Cc 10a-25	---
Saponification number	176 to 184	176 to 184	Cd 3-25	---
Unsaponifiable, maximum				
percent	0.7	0.8	Ca 6a-40	---
Iodine number (Wijs)	82 to 88	80 to 88	Cd 1-25	---
Appearance	Clear	Clear	---	D555

Castor oil for addition to the strategic stockpile was bought on Government specifications. The oil could be acceptable whether recovered by a pressing operation or by solvent extraction. In commercial grades No. 1 castor oil is recovered by a pressing operation and after being refined is clear and almost colorless. The No. 3 oil, however, is recovered by solvent extraction and even after refinement varies from yellow to brown in color and contains certain impurities due to the solvent action on the pomace. The trade no longer recognizes an intermediate or No. 2 grade.

Only those stockpile specifications for castor oil considered important for assessing changes in the characteristics that occur in beans during storage were included in this study.

Specific Gravity

This term as used in stockpile specifications for castor oil is the ratio of the weight of a unit of the oil to the weight of an equal volume of water at a temperature of 15.5° C. To meet National Stockpile specifications grade No. 1 oil must have a specific gravity within the limits of 0.959 and 0.965, and No. 3 oil within 0.957 and 0.965.

The specific gravity of the oil extracted from the 100-percent whole beans, the 100-percent cracked and broken beans, and the field-run beans each averaged 0.962 for the 5-years' storage period. The oil from whole beans varied from 0.959 to 0.965, from cracked and broken beans 0.956 to 0.964, and from field-run beans 0.958 to 0.966. The average deviation for each of the three types of samples was 0.001 which is equivalent to 0.1 percent variation. This amount of variation in specific gravity is rather insignificant and may be considered within the tolerance of experimental error.

The oil from all 54 samples of whole beans, in storage up to 5 years, continued to meet stockpile specifications concerning specific gravity for No. 1 oil (fig. 2). However, 2 of the 54 samples from cracked and broken beans and 2 of those from field-run beans did not.

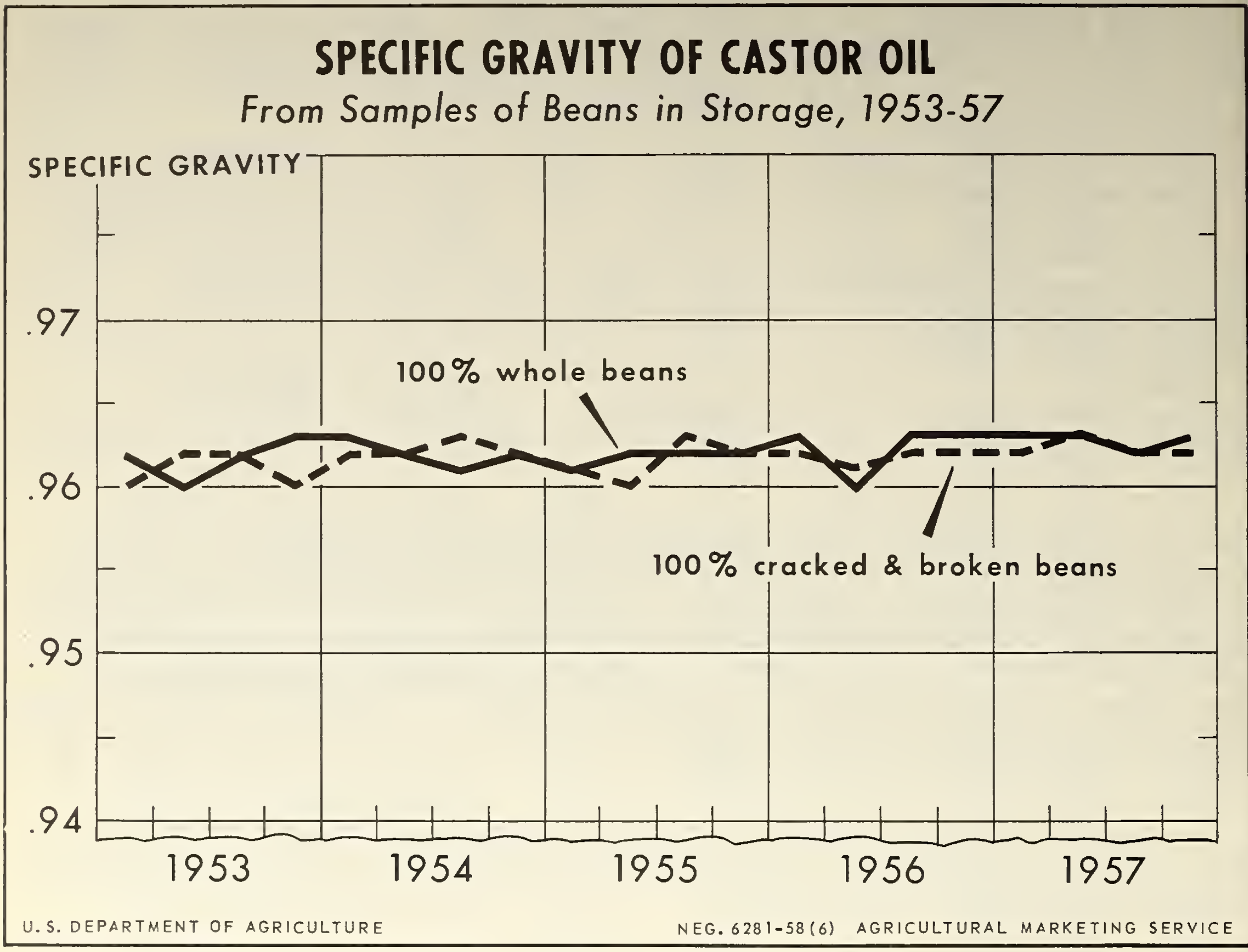

Figure 2

The high specific gravity of castor oil is a characteristic which distinguishes this oil from most other fatty oils. Moreover, the relative stability of the specific gravity of this oil is a feature that may be of considerable interest to any farmer or processor contemplating the storing of castorbeans. With respect to this important characteristic, castorbeans can be stored for at least 5 years without loss in quality.

Color (Gardner number)

The color of castor oil is important and may vary over a considerable range. Color in the crude oil may affect subsequent processing and the end use of the product. The color of castor oil varies with the variety of seed,

level of plant nutrition, environment during growth, and the processing method used to recover the oil. As determined by the Gardner 1933 standards, the maximum color for No. 1 oil is 3, and for No. 3 oil, 8. The color is determined by comparing the oil with standards of definite color composition for which numbers have been assigned to indicate the color level. The lower the Gardner number, the lighter and clearer the oil. Since the determination of color by this method is subjective, some allowance should be made for experimental error.

Throughout the first year of storage, the oil from the whole beans as well as that from the cracked and broken beans, met stockpile color specifications for No. 1 oil--varying between Gardner color 2 and 3 (fig. 3). Toward the end of the second year, the oil became somewhat darker, especially the oil from the cracked and broken beans. For the second year, 2 of the 18 samples of oil from the whole beans and 6 of the 18 from the cracked and broken beans, exceeded the color maximum for No. 1 oil. The average color of oil from both lots met specifications for No. 1 oil. During the third year, however, the average oil color for both lots exceeded the maximum for No. 1 oil as 70 percent of the samples had excessive color. For the fourth and fifth years, the oil from all lots graded No. 3 with respect to color. Throughout the storage experiment the color of the oil from the field-run beans was similar to that from the other 2 lots.

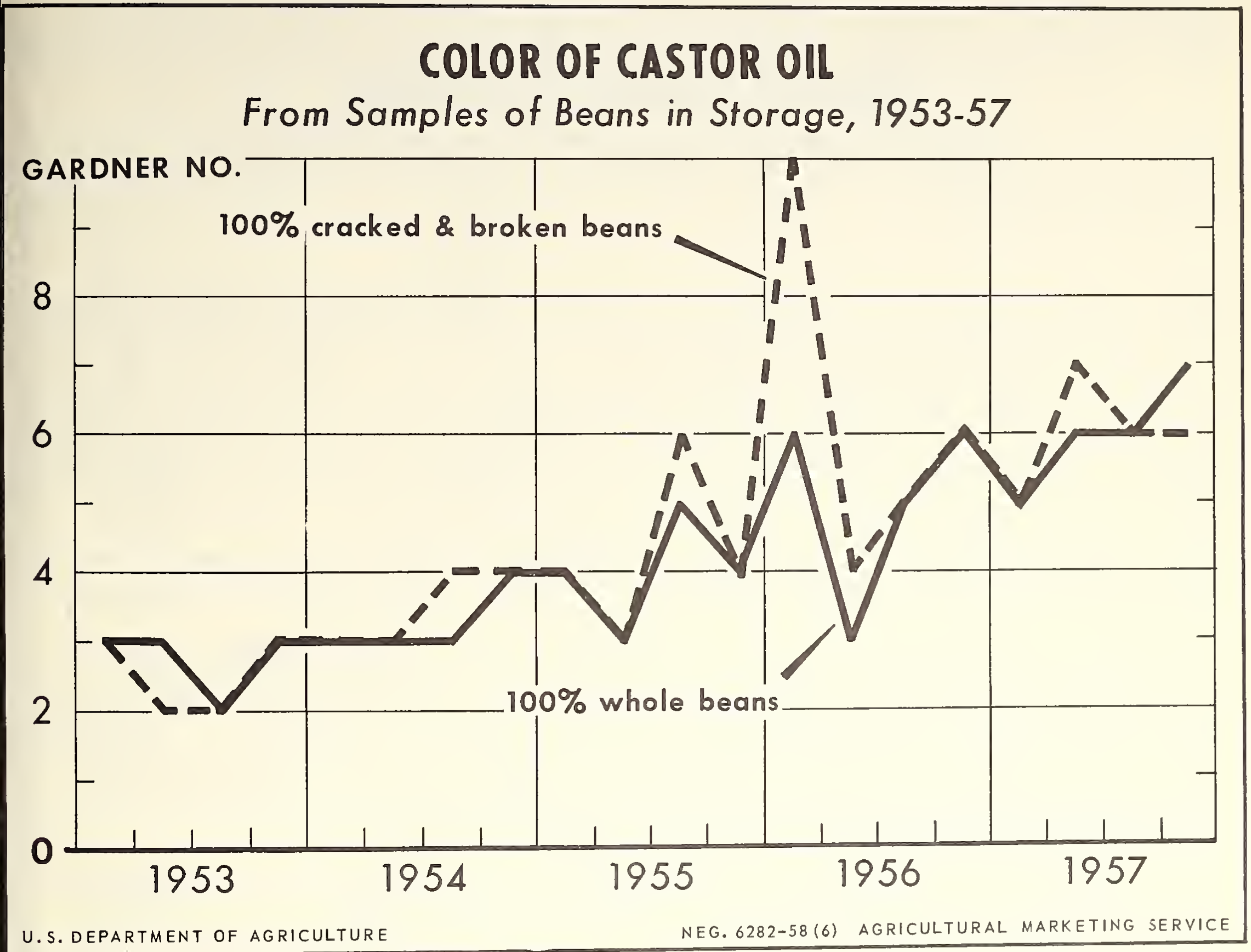

Figure 3

Free Fatty Acid (as oleic)

The free fatty acid requirements as set forth in the National Stockpile Specifications are stated in terms of "neutralization number," which equals almost twice (1.99) the free fatty value (as oleic). Therefore, stockpile specifications require that free fatty acid content of crude castor oil must not exceed 1.5 percent for No. 1 and 6.0 percent for No. 3.

For the first year of storage, free fatty acid content of the oil from the whole beans and the cracked and broken beans varied in a similar manner with no discernible trend (fig. 4). In 8 of the 14 samples for that year, free fatty acid of the oil from the cracked and broken beans was higher than that from the whole beans and in 1 case the free fatty acid content of the oil from both types of samples was the same. The average free fatty acid content was 0.32 percent for oil from the whole beans and 0.38 percent for the cracked and broken beans. The range in variation was 0.45 percent for both types of sample The neutralization number averaged 0.64 percent for the oil from the whole bean and 0.76 percent for that from the cracked and broken beans, both readings of which were well within the tolerance for No. 1 oil for stockpiling purposes.

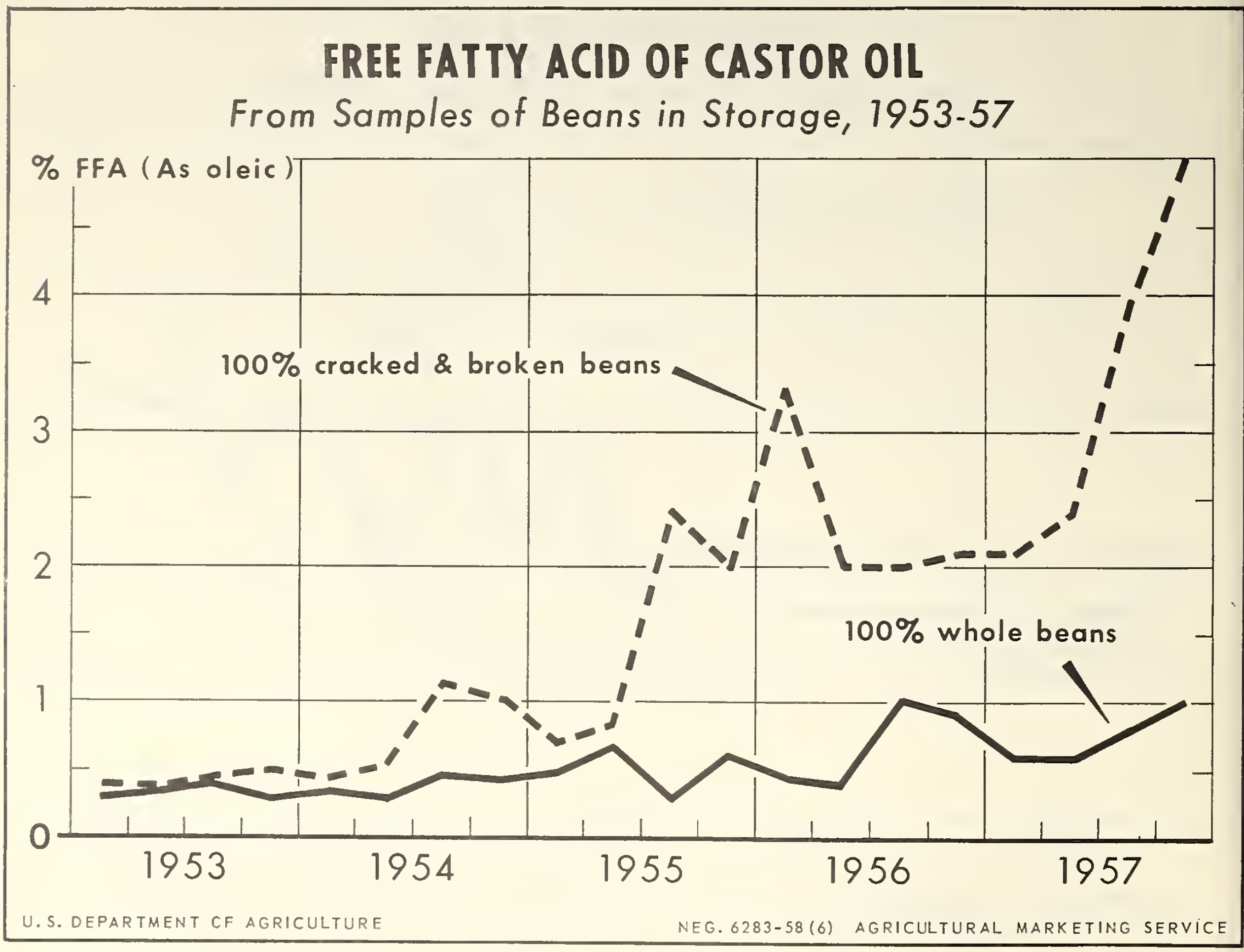

Figure 4

During the second year of storage, the free fatty acid content in oil from the whole beans averaged 0.35 percent or only slightly higher than for the year before, with a range of 0.28 percent. Toward the end of the second year of storage, however, the free fatty acid content appeared to be increasing. Free fatty acid content of the oil from cracked and broken beans almost doubled, increasing from 0.38 percent to 0.72 percent. The oil, however, still met stockpile specifications for No. 1 oil.

During the third year, the free fatty acid in the oil from the whole beans increased to an average of 0.50, still well within tolerance for No. 1 oil. The range in variation of free fatty acid content was 0.70 percent, compared with 1.78 percent in oil from the cracked and broken beans. The free fatty acid content of oil from cracked and broken beans continued to increase to an average of 1.01 percent, which was still within the tolerance for No. 1 oil for stockpiling. The sharp increase in acid content toward the end of that year with 2 readings up to 4.0 percent or more, suggests the possibility of some experimental error. However, subsequent readings though taken at greater intervals, indicate that these beans were going out of condition.

During the fourth and fifth years, the oil from the whole beans continued to meet stockpile specifications for No. 1 oil with respect to free fatty acid content which averaged 0.68 percent and 0.75 percent, respectively, for those years. During the fourth and fifth years of storage the oil from none of the 8 oil samples from cracked and broken beans met stockpiling requirements for No. 1 oil because of excessive free fatty acid which averaged 2.35 percent and 3.35 percent, respectively, for those 2 years. For the fifth year, the range in variation for the acid content in oil from these beans was 4.85 percent.

Although the free fatty acid content of oil from the 100-percent cracked and broken beans increased much faster and averaged much higher than that from the whole beans, this would not be typical of usual storage since field-run beans normally contain only around 3 to 5 percent cracked and broken beans. Moreover, during the 5 years' storage period the representative samples of field-run beans containing 4 percent cracked and broken beans met the stockpile specifications for No. 1 oil with respect to free fatty acid content. However, the oil from 1 of 4 samples drawn during the fourth year and the last 2 of 4 for the fifth year exceeded the free fatty acid tolerance for No. 1 oil. The free fatty acid values for the fourth and fifth years of storage averaged 1.2 and 1.5 percent, respectively, both of which were within the tolerance.

Excessive free fatty acid content, which reduces the quality and value of castor oil, may result from (1) inferior quality of the beans, (2) improper storage and handling, or (3) inadequate control during the extraction process. Reduction of excessive free fatty acid of castor oil during refinement increases the refining loss and the cost of refining. To the extent that growers and marketing agents can improve their operations so as to reduce the acid content of castor oil by other means than refinement, the costs of marketing this commodity should be reduced.

Iodine Number

The iodine number is a measure of the relative "unsaturation" of the castor oil and is used to classify oils according to their drying potential. To meet stockpile requirements, No. 1 castor oil must have an iodine number between 82 and 88, and No. 3 oil between 80 and 88, as determined by the Wijs method. Unmodified castor oil has an iodine number below 100 and is nondrying in character. However, castor oil can be converted to dehydrated castor oil which has drying properties. The iodine number of dehydrated castor oil varies from around 109 to 140 5/, making it suitable for use where a drying oil is required.

During the 5 years' storage period, the iodine number of the oil from the whole beans varied from 83 to 90 or a range of 7 points compared with the variation in cracked and broken beans from 82 to 89 or a range of 7 points also (fig. 5). The iodine number of the oil from both of these 2 types of samples averaged 87 for that period. The iodine values for these 2 types of samples

5/ Jamieson, George S. Vegetable Fats and Oils. Ed. 2, 1943. Reinhold Publishing Corp., p. 52.

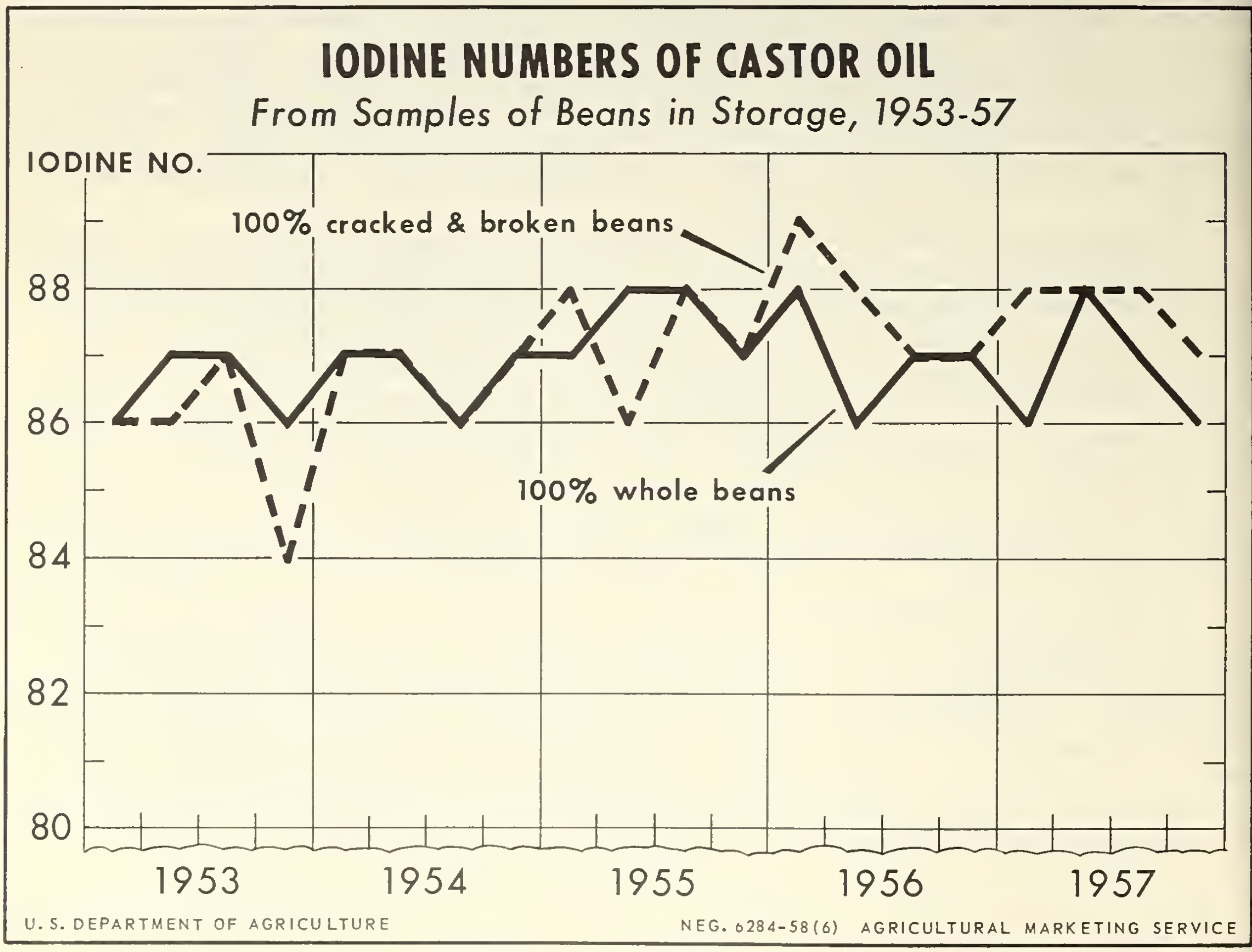

Figure 5

tended to follow a similar pattern of variation; however, the variation was not great. While the iodine number of the oil from cracked and broken beans was lower than that of the oil from whole beans in some instances, and higher in others, there was no significant difference between their averages during the storage period.

The level and the variation pattern of the iodine number of oil from the field-run samples did not differ significantly from those for the other 2 types of samples. About 94 percent of all samples for the 5-year storage period met specifications for No. 1 oil with respect to iodine number.

Of the 54 samples analyzed during the 5 years the beans were in storage, the iodine number of the oil from cracked and broken beans was (1) the same as the iodine number of oil from whole beans in 25 samples, (2) more than the iodine number of oil from whole beans in 16 samples, and (3) less than the iodine number of the oil from whole beans in 13 samples.

In view of the findings, it appears that castorbeans maintain quality in storage with respect to the iodine value of the oil.

Unsaponifiable Matter

National Stockpile specifications permit a maximum of 0.7 percent unsaponifiable matter for No. 1 castor oil and a maximum of 0.8 percent for No. 3 oil. Unsaponifiable matter includes those substances which are frequently found dissolved in castor oil and which are not saponified by the caustic alkalies but are soluble in the ordinary fat solvents. The amount of unsaponifiable matter in the oil depends on the degree of refining.

During the 5 years' storage period the unsaponifiable matter in the oil from both the whole beans and cracked and broken beans on an average remained well within the maximum limits required by stockpile specifications for No. 1 oil. In only 4 samples of oil from the whole beans and 1 for the cracked and broken beans did the unsaponifiable matter exceed the allowable maximum for No. 1 oil. During this period the percentage of unsaponifiable matter in the oil samples from the whole beans tended to increase somewhat during the first 2 years of storage, then declined each year during the remaining 3 years. The average percentage of unsaponifiable matter in the oil from these beans, by years, was 0.50, 0.58, 0.56, 0.54, and 0.48, respectively. For this same period, the percentage of unsaponifiable matter in the oil from cracked and broken beans increased on an average during the first 2 years, declined in the third year, reached the highest point in the fourth year, and again declined in the fifth year. The average percentages of unsaponfiable matter in the oil from cracked and broken beans by years was 0.52, 0.54, 0.53, 0.55, and 0.51, respectively.

The pattern of variation for both types of samples was about the same (fig. 6). The average percentage of unsaponifiable matter for the oil from both the whole beans and the cracked and broken beans was 0.53. The variation

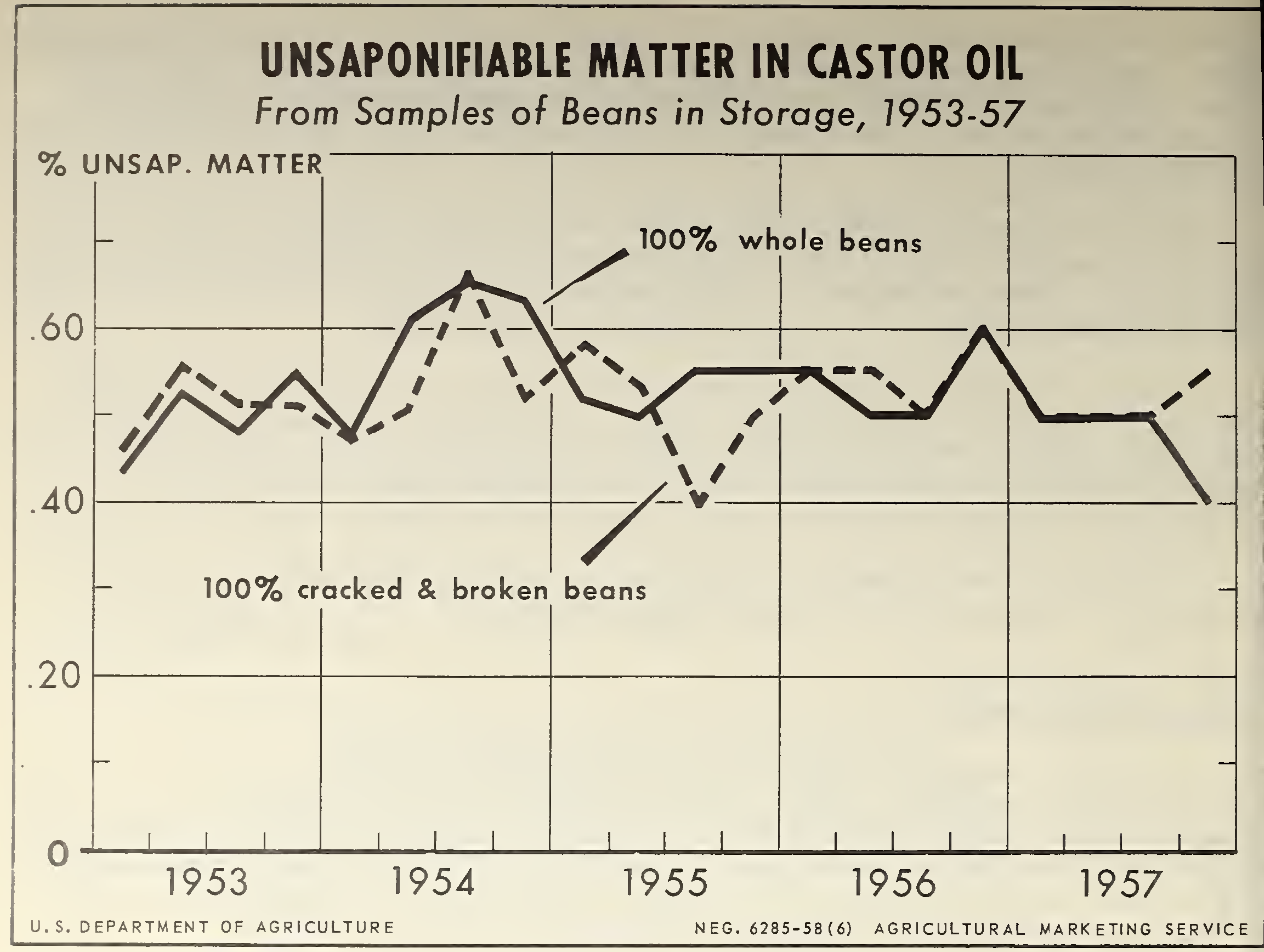

Figure 6

was from 0.21 percent to 0.80, or a range of 0.59 percent for the whole beans and from 0.26 percent to 0.83 percent, or a range of 0.57 percent for the cracked and broken beans.

MOISTURE CONTENT OF BEANS IN STORAGE

Excessive moisture is the most frequent cause of deterioration of castorbeans, and in beans in storage may result in heating and molding. As moisture content in beans decreases, more dry matter, and consequently more oil, is included in a pound of beans. Moisture content of the samples of the whole beans at the time they were placed in storage for research purposes was 6.4 percent, and of the cracked and broken beans, 5.7 percent.

The castorbeans tended to absorb moisture during the cold months of storage and to dry out considerably during the hot months (fig. 7), thus giving a seasonal variation in moisture content. The variation in moisture content

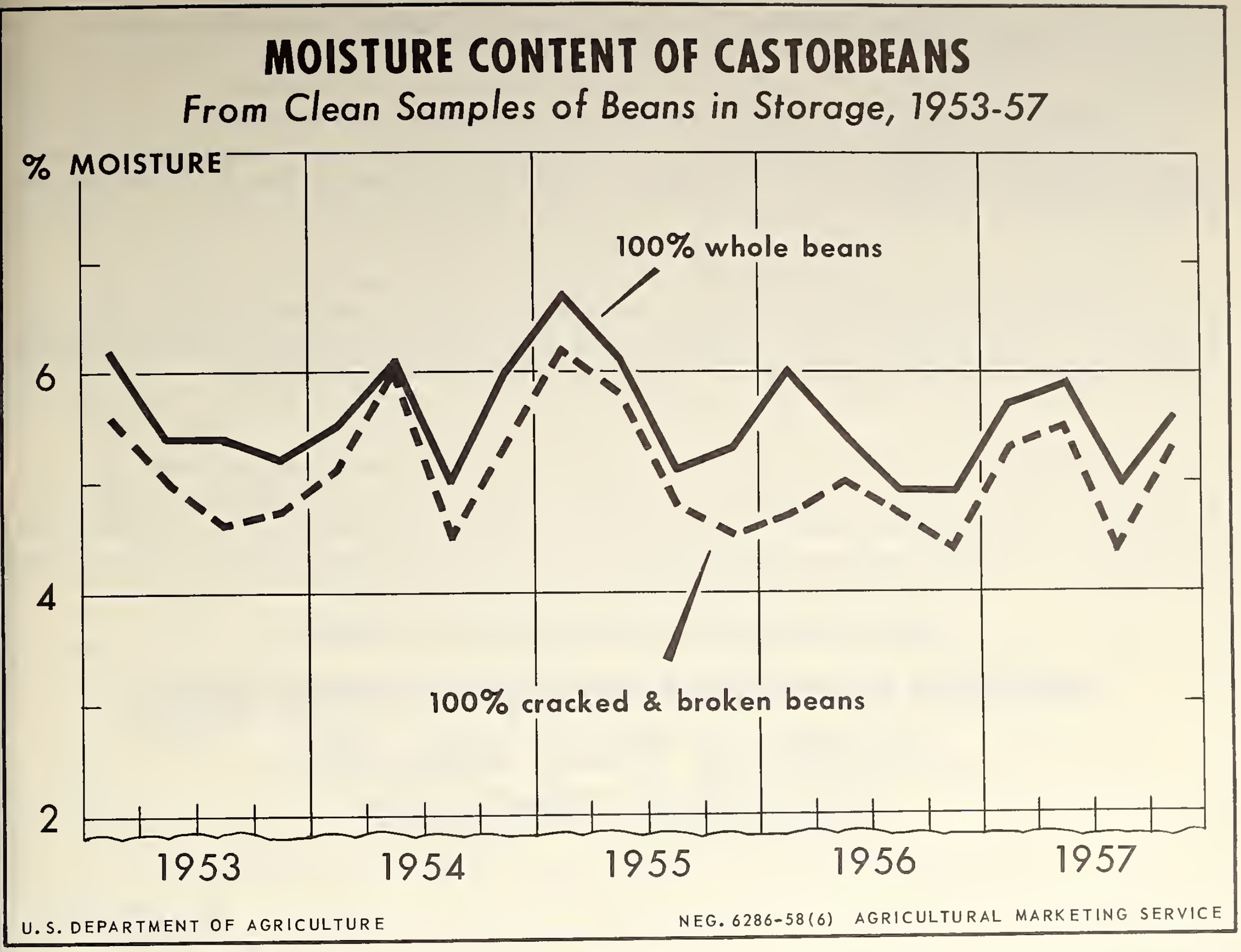

Figure 7

tended to follow the same pattern for both whole beans and cracked and broken beans. However, the cracked and broken beans contained less moisture. The moisture in these beans averaged 5.1 percent compared to 5.6 percent for the whole beans, or an average difference of 0.5 percent (excluding two erratic samples, one whole bean sample in August 1953 and one cracked and broken sample in June 1954). The average moisture content of the field-run beans was the same as that for the whole beans. Moreover, the variation in moisture for the field-run beans was very similar to that for the whole beans.

Throughout the storage period, the moisture content for both whole beans and cracked and broken beans was higher in winter than in summer. For whole beans, the average moisture content was 6.1 percent during the winter months and 5.1 percent during the summer months. For cracked and broken beans, the average moisture content was 5.4 percent in winter months and 4.6 percent in summer months. Thus, from summer to winter, the average moisture content increased 1.0 percentage point in whole beans and 0.8 percentage point in cracked and broken beans. The average moisture content for whole beans was 19.6 percent higher in winter than in summer, whereas that for cracked and broken beans

was 17.3 percent higher. As cracked and broken beans have lost all or part of their seed coats and are more oily, they are not likely to absorb as much moisture as whole beans.

A similar analysis was made of the moisture content of field-run beans. The difference between the average moisture content of these beans during the summer and winter months was the same as that for the whole beans (1.0 percentage point).

In studies on the relationship of temperature to moisture content of castorbeans, as the temperature rose, moisture content decreased. The moisture content of whole beans, cracked and broken beans, and average normal quarterly temperature during the storage period are shown in figure 8. 6/

6/ For the first $2\frac{3}{4}$ years during which the beans were in storage at Whitesboro, Texas, the climatological data from the Sherman Station, about 25 miles away, were used as there is no weather station at Whitesboro. After the beans were moved to Stephenville, Tex., in July 1955, local climatological data were used.

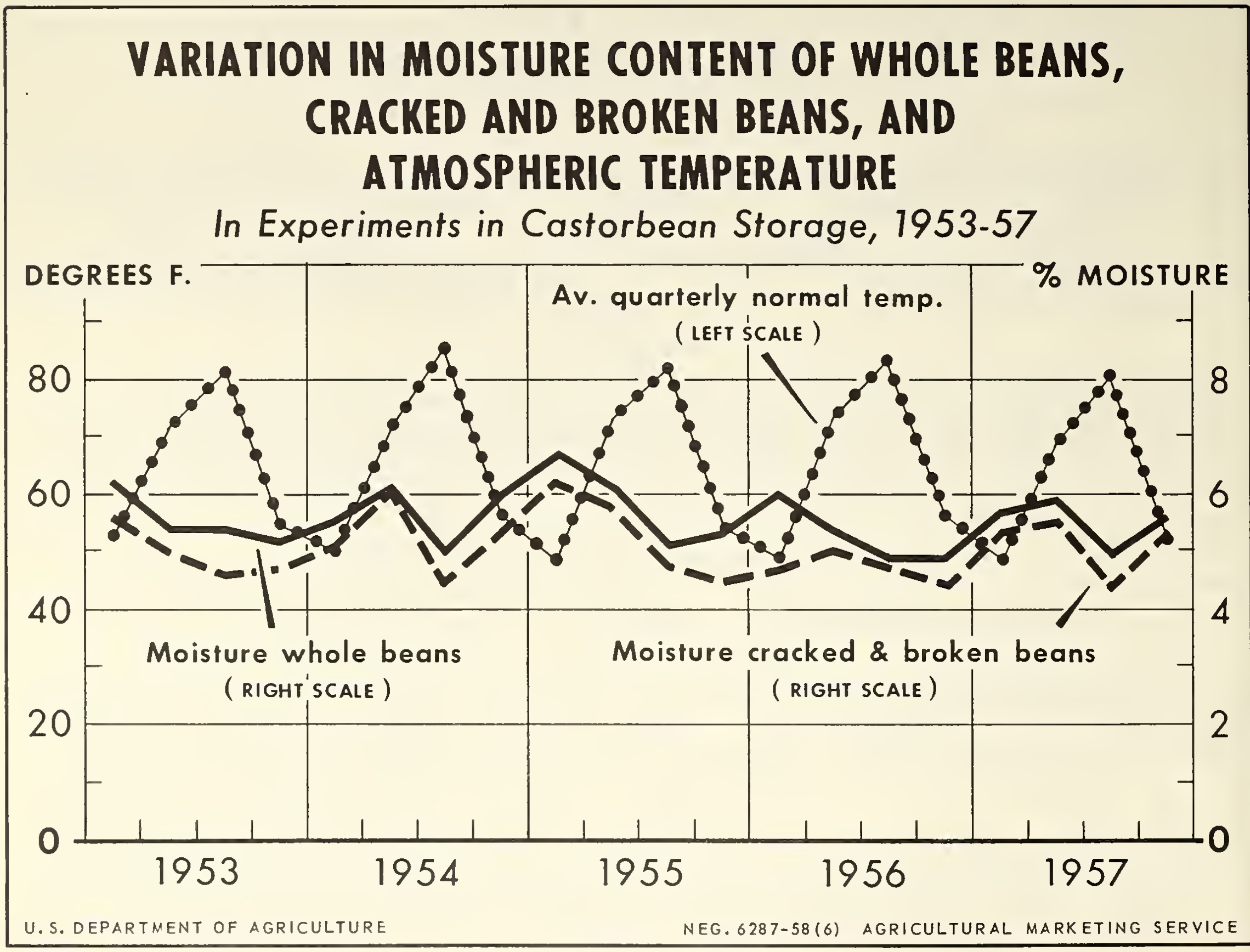

Figure 8

Moisture content of both whole sound beans and cracked and broken beans varied inversely in a linear relationship with average weekly temperature during the storage period. The coefficients of correlation were -0.59 and -0.47, respectively. Temperature explained about 34 percent of the variation in moisture content of whole sound beans and about 22 percent of cracked and broken beans. On an average, with each degree increase in temperature, moisture content decreased about 0.022 percent for whole beans and about 0.020 percent for cracked and broken beans. The standard error of estimate was 0.48 for the whole beans and 0.56 for the cracked and broken beans (fig. 9). 7/

7/ Standard error of estimate is a measure of the variation or scatter of plotted observations about the line of regression. In a normal distribution, one standard error includes about two-thirds of the cases when measured plus or minus the line of regression.

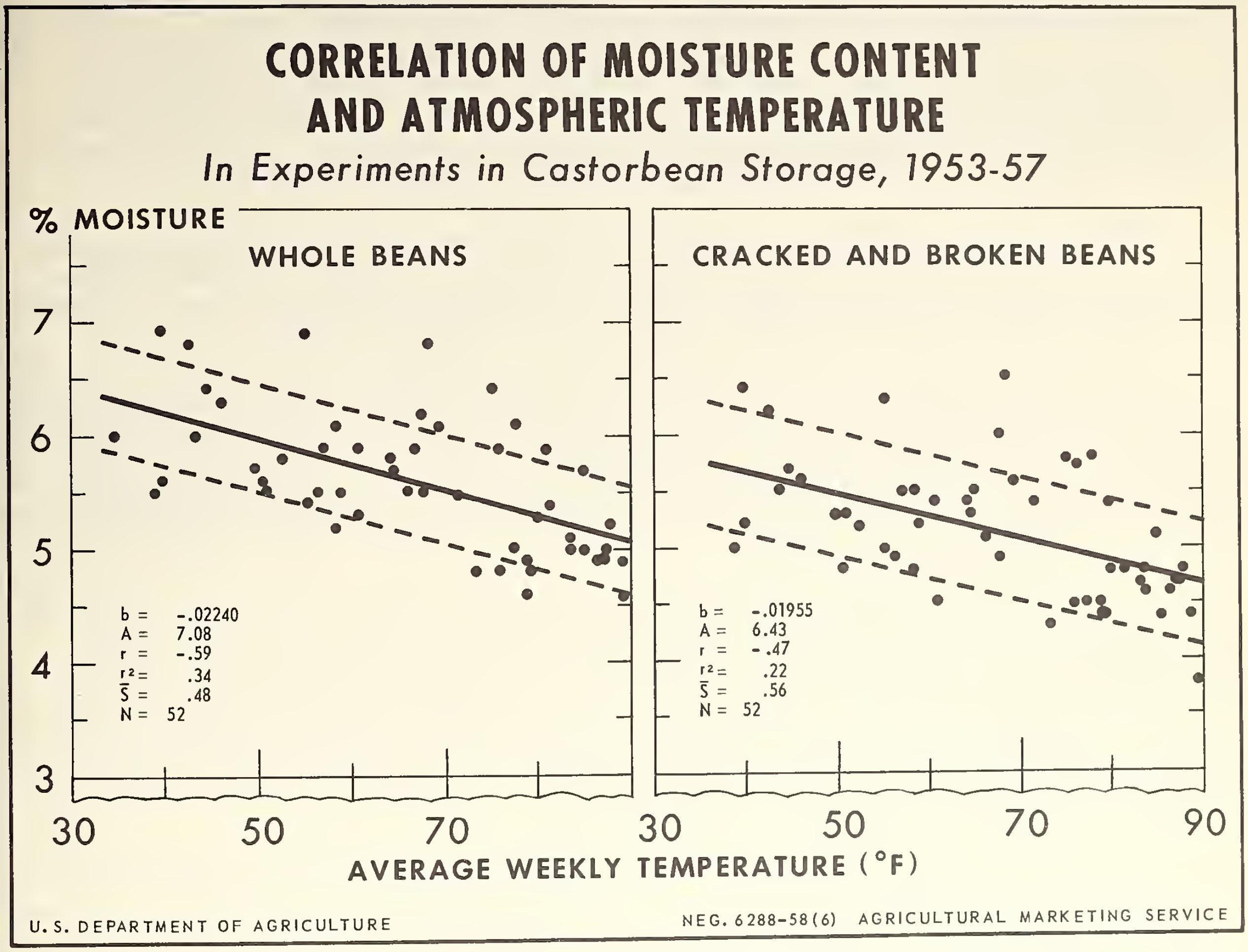

Figure 9

From the scatter diagram, it can be seen that within the range of the temperature during the storage period--39° to 89°--average moisture, as measured by the fitted straight line, decreased from 6.3 to 5.0 percent for the whole beans. The decrease in moisture for cracked and broken beans was from 5.7 to 4.7 percent within that range of temperature.

Precipitation is another factor affecting the moisture content of castorbeans in storage. During the $2\frac{3}{4}$ years when the beans were stored at Whitesboro, Tex., the average monthly precipitation (in inches) by quarters were as follows: winter, 2.7; spring, 4.7; summer, 3.0; and fall, 3.7. During the $2\frac{1}{4}$ years when the beans were in storage at Stephenville, Tex., the average precipitation readings by quarters were 1.2, 6.1, 0.9, and 2.1, respectively. Precipitation and moisture content of the beans showed a positive though insignificant relationship. The simple correlation coefficient was 0.28. The resulting coefficient of determination 8/ indicates that only about 8 percent of the variation in moisture content of field-run castorbeans is accounted for by the variation in rainfall. Precipitation thus appears to be only about one-fourth as important as temperature in explaining the variation in moisture.

Relative humidity also was found to be positively correlated with the moisture content of castorbeans during the storage period. The coefficient of correlation was 0.47 which indicates that about 22 percent of the variation in moisture content is accounted for by variation in relative humidity.

Thus, from this analysis it appears that of the different climatic factors used in explaining the variation in moisture content of field-run castorbeans (1) temperature is the most significant, (2) relative humidity is only slightly less significant, and (3) precipitation is rather insignificant.

It is interesting to note that the correlation coefficient between moisture content and temperature is reduced from -0.56 to -0.46 when the effect of precipitation and relative humidity is eliminated. Then only 21 percent of the variation in moisture content was explained by temperature. The correlation between temperature and precipitation was about -0.02 and between temperature and relative humidity was -0.57.

The correlation coefficient between moisture content and precipitation is similarly reduced from 0.28 to 0.26 when temperature and relative humidity are held constant, thus explaining about 7 percent of the variation in moisture content. When the effect of temperature and precipitation is eliminated, the correlation coefficient between moisture content and relative humidity is reduced from 0.47 to 0.04. Then only 4 percent of the variation in moisture content was explained by relative humidity.

The multiple correlation coefficient, measuring the relative importance of temperature, precipitation and relative humidity combined in accounting for the

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8/ Coefficient of determination is the square of the coefficient of correlation and measures the percentage of variation explained in the dependent variable (moisture content in this case) when associated with one or more independent variables.

differences in moisture content of the castorbeans was 0.63. From this value, it can be assumed that about 39 percent of the variation in moisture content was associated with variation in temperature, precipitation, and relative humidity. The standard error of estimate was 0.45. The results of the correlation and regression analyses are summarized in table 5.

Conversely, about 60 percent of the variation in moisture content was not accounted for by the foregoing analysis made of temperature, precipitation, and relative humidity. 9/ To what extent the unexplained variation was due to a natural drying of the beans or other factors cannot be ascertained from the data. The average moisture content of samples from all 3 types of samples decreased as they dried out during storage. For whole beans the average moisture loss was 0.9 percentage point or 14 percent, for cracked and broken beans 0.6 percentage point or 11 percent, and for the representative samples 0.6 percentage point or 10 percent.

The above discussions explain in part the changes in moisture content of the castorbeans. If a sufficient number of observations of changes in temperature and humidity could have been made, perhaps most of the changes in moisture content of the beans could have been explained.

QUALITY AND QUANTITY INTERRELATIONSHIPS AND ECONOMIC IMPLICATIONS

Of the interrelationships in this study several points stand out:

(1) Castorbeans store well under normal conditions. Therefore, a farmer might increase his net returns by storing his beans for a while rather than selling them at harvest-time when the market facilities may be congested and prices relatively low. Farm storage could become more important as domestic production increases. It could help in moderating sharp price fluctuations of this commodity. The fact that castorbeans are storable enables processors to acquire large quantities of beans whenever prices are favorable to them and store the beans until needed without loss in quality. Insofar as ideal storage practices help in conditioning the beans, castorbean storage may help improve milling efficiency and thereby help reduce processing costs.

After 2 years in storage, the oil from all 3 types of samples met National Stockpile Specifications for No. 1 castor oil. The oil from the cracked and broken beans was slightly lower in quality than that from whole sound beans with respect to color and free fatty acid content. However, the average farmer's lot of beans generally contains only from 3 to 5 percent cracked and broken beans, and when oil from samples of 100-percent whole beans was compared with that from beans containing approximately average proportions of cracked

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9/ Coefficient of nondetermination is the square of the coefficient of alienation as well as the complement of the coefficient of determination. It measures the percentage of variation unexplained in the dependent variable when associated with one or more independent variables.

Table 5.--Relationships between moisture content of castorbeans and temperature, precipitation, and relative humidity during storage, 1953-57

Variables			Coefficients of--								
			Regression			Determination			Correlation		
Dependent	Independent	Held constant	Whole beans 1953-54	Whole beans 1953-57	Field-run 1953-57	Whole beans 1953-54	Whole beans 1953-57	Field-run 1953-57	Whole beans 1953-54	Whole beans 1953-57	Field-run 1953-57
Moisture	Temperature	None	-0.019	-0.022	-0.021	0.301	0.346	0.317	-0.548	-0.588	-0.563
Do.	do.	Precipitation	-.017	-.022	-.021	.277	.364	.339	-.527	-.603	-.582
Do.	do.	Precipitation and relative humidity	-.015	-.020	-.020	.200	.297	.213	-.448	-.545	-.462
Moisture	Precipitation	None	.169	.092	.081	.155	.029	.080	.393	.169	.283
Do.	do.	Temperature	.130	.104	.079	.126	.055	.110	.356	.235	.331
Do.	do.	Temperature and relative humidity	.110	.057	.072	.083	.014	.066	.289	.118	.256
Moisture	Relative humidity	None	.035	.020	.030	.200	.156	.223	.447	.394	.472
Do.	do.	Precipitation	.027	.021	.027	.117	.131	.161	.342	.362	.401
Do.	do.	Temperature	.019	.012	.014	.069	.081	.049	.262	.284	.221
Do.	do.	Temperature and precipitation	.011	.010	.003	.023	.040	.002	.151	.201	.043
Moisture	Temperature, precipitation, and relative humidity	None	---	---	---	.403	.407	.393	.635	.638	.627
Temperature	Precipitation	None	-2.287	.510	-.125	.034	.001	.000	-.184	.035	-.016
Temperature	Relative humidity	None	-1.030	-.409	-.979	.211	.089	.329	-.460	-.298	-.574
Do.	do.	Precipitation	-1.033	-.538	-1.243	.184	.123	.413	-.429	-.351	-.643
Precipitation	Relative humidity	None	.073	.042	.103	.164	.199	.223	.405	.446	.472
Do.	do.	Temperature	.073	.048	.151	.135	.229	.320	.367	.479	.566

While the analysis of data for the field-run beans is discussed in the report, similar data for whole beans is included in the table to permit comparison with such data in MRR No. 106.

and broken ones, there was very little difference in free fatty acid content which was 0.34 percent and 0.35 percent, respectively.

(2) The quality of oil from stored castorbeans decreased over time. During the third year of storage, the oil from all 3 types of samples had an average Gardner color number of 4, thus becoming No. 3 grade with respect to this quality factor. Throughout the remaining storage period, however, the oil from whole beans and field-run beans continued to meet all the stockpile specifications for No. 1 oil, except for color. In no year did individual oil color observations exceed 8 or average more than 6 for these 2 types of samples. Their oil color number for the storage period averaged 4. During the fourth and fifth years of storage, the free fatty acid content of oil from the cracked and broken beans averaged 2.4 percent and 3.4 percent, respectively, thus exceeding the maximum limit of 1.5 percent for No. 1 oil, but still well within tolerance for No. 3 oil. For these 2 years, the average color number of the oil from this type of sample averaged 5 and 7, respectively, still within the color tolerance for No. 3 oil. Except for color and free fatty acid, the oil from cracked and broken beans continued to meet Stockpile Specifications for No. 1 oil throughout the storage period.

No. 3 grade castor oil is suitable for industrial uses and since the bulk of all castor oil used in this country goes for such uses, the oil from beans stored up to 5 years should still meet industrial requirements. Moreover, the average price of No. 3 technical grade castor oil was 22.1 cents per pound compared to 23.1 cents per pound for No. 1 grade oil, or a difference of only 1 cent per pound for 1957.

The application of these relationships, however, has certain limitations. First, no attempt was made to segregate cracked and broken beans in storage to determine their storage characteristics and keeping qualities. The whole beans and cracked and broken beans were stored together in bulk. No reason is apparent from the analysis, however, why freshly hulled beans from the current crop, with no more than 6 percent moisture and 5 percent of cracked and broken beans, should deteriorate significantly in storage for at least 2 years. Moreover, there is no apparent reason why they should not meet stockpile specifications for No. 1 oil, except for color and free fatty acid content for at least 5 years.

Second, no investigations were made into the keeping quality of the castor oil in storage. It is the opinion of some in the trade that oil from cracked and broken beans deteriorates or goes out of condition more quickly than does the oil from whole beans. Further research is needed to determine the relative keeping qualities of each of these oils. If the oil is further processed or used immediately after extraction, there is little reason to believe it would need special treatment or handling.

(3) Cracked and broken beans contain more oil per pound than whole beans. In the storage experiment at Whitesboro and Stephenville, Tex., samples of cracked and broken beans yielded 9.3 percent more oil for the first 2 years and an average of 8.7 percent more oil for the 5 years' storage period. This 9.3 percent (or 5.0 percentage points) difference in oil-yield per ton converted to

market value at 23 cents per pound for No. 1 oil would be worth $21.85 (assuming a 95 percent recovery rate). 10/

The 8.7 percent (or 4.6 percentage points) difference in oil-yield per ton of whole beans and cracked and broken beans, converted to market value at 22 cents 11/ per pound of No. 3 technical grade oil, would be worth $19.37. (The oil became No. 3 grade with respect to color during the third year of storage.)

Prior to 1956, farmers' beans were docked for cracked and broken beans in excess of 3 percent. Consequently, farmers were penalized for cracked and broken beans in their lots which actually contained more oil than whole sound beans. In the spring of that year, however, the trade announced that cracked and broken beans are no longer considered as a quality factor in determining the basis for the purchase of castorbeans. Thus, recognition is now being given to cracked and broken beans in that no penalty is assessed.

(4) The oil content of castorbeans tends to decrease during storage. The average loss in oil content of whole beans, cracked and broken beans, and field-run beans during 5 years' storage was 1.2, 1.6, and 1.3 percentage points, respectively. These values represent 2.2, 2.7, and 2.4 percent oil loss per ton for these 3 types of samples. These percentages of No. 3 grade oil, converted to pounds and then to market value at 22 cents per pound, would amount to economic losses of $5.23, $6.97, and $5.77, respectively, per ton of beans stored 5 years.

(5) Recent experience has indicated that castorbeans can be grown successfully on a commercial basis and can compete effectively with other crops for land use in certain areas. In adaptable areas of the Southwest, southern great plains, and in California, castorbeans may be used to replace some acreage of crops such as cotton which have been restricted by production control programs. The need for replacement crops along with improved varieties of castorseed and harvesters which also hull in one operation are factors enhancing the prospects for expansion of domestic castorbean acreage. As the domestic production of castorbeans is increased, various aspects relating to the marketing of this crop, including storage and changes in quality of the oil from stored beans, may be expected to increase in importance.

10/ 1957 average wholesale price per pound, No. 1 castor oil, tanks, New York.

11/ 1957 average wholesale price per pound, No. 3, technical, drums, carlots, f.o.b. New York.

APPENDIX

Table 6.--Whole castorbeans: Chemical analysis of samples of Connor variety (dryland) and of the oil extracted from them, the beans having been taken from storage during 1953-57

100 PERCENT WHOLE BEANS

Sample number	Date sample was drawn	Months in storage	Castorbean analysis: Moisture clean sample	Castorbean analysis: Oil: Clean moisture free	Castorbean analysis: Oil: Whole sample	Castor oil analysis: Specific gravity	Castor oil analysis: Color (Gardner)	Castor oil analysis: Neutralization number	Castor oil analysis: Free fatty acid (as oleic)	Castor oil analysis: Iodine number	Castor oil analysis: Unsaponifiable matter
	1953	Number	Percent	Percent	Percent	Percent	Number	Number	Percent	Number	Percent
1	2-20	5	6.4	54.6	51.2	0.962	3	0.67	0.34	86	0.37
2	3-26	6	5.9	54.5	51.3	.961	3	.48	.24	85	.49
3	4-14	6½	5.5	52.6	49.7	.962	3	.52	.26	87	.42
4	4-29	7	5.8	53.8	50.7	.961	3	.82	.41	86	.38
5	5-15	7½	5.7	54.7	51.6	.959	3	.82	.41	88	.60
6	5-29	8	5.4	53.2	50.4	.960	2	.16	.08	86	.48
7	6-15	8½	5.2	54.3	51.5	.959	3	.64	.32	87	.59
8	6-30	9	4.9	54.3	51.7	.961	2	.83	.42	88	.62
9	7-15	9½	5.0	53.2	50.5	.965	2	1.05	.53	86	.70
10	7-31	10	5.0	53.8	51.1	.959	3	.55	.28	88	.57
11	8-15	10½	6.7	55.8	52.1	.959	2	.97	.49	86	.41
12	8-31	11	5.3	53.3	50.4	.963	2	.58	.28	86	.28
13	9-15	11½	4.8	53.9	51.3	.962	2	.67	.35	87	.46
14	10-6	12	4.8	54.2	51.2	.965	2	.26	.13	89	.57
15	10-20	12½	4.8	54.7	52.1	.964	3	.62	.31	83	.77
16	11-3	13	5.2	52.2	49.4	.961	3	.57	.29	83	.64
17	11-30	14	5.5	53.4	50.5	.961	2	.74	.37	86	.55
18	12-31	15	5.5	54.2	51.2	.964	4	.66	.33	87	.21
	1954										
19	1-25	16	5.6	54.5	51.4	.963	3	.80	.40	87	.52
20	2-23	17	5.5	54.8	51.8	.962	3	.52	.26	87	.39
21	3-29	18	5.5	54.5	51.5	.964	2	.60	.30	86	.53
22	4-15	18½	5.9	54.1	50.9	.962	3	.56	.28	86	.64
23	5-3	19	6.1	56.7	53.2	.962	2	.47	.24	87	.55
24	5-14	19½	6.1	53.2	50.0	.962	3	.54	.27	89	.64
25	6-1	20	6.4	54.7	51.2	.961	3	.53	.27	89	.59
26	6-14	20½	5.9	53.9	50.7	.961	3	.61	.30	86	.63
27	7-12	21½	4.6	52.3	49.9	.961	3	.63	.32	87	.67
28	8-2	22	5.7	53.9	50.8	.961	4	.89	.45	87	.71
29	8-17	22½	4.9	54.0	51.4	.960	2	.85	.43	85	.78
30	9-2	23	5.0	54.4	51.7	.961	3	.98	.50	86	.55
31	9-14	23½	4.6	53.7	51.2	.960	3	1.04	.52	87	.55
32	10-4	24	6.3	53.1	49.7	.962	3	1.04	.52	85	.60
33	10-18	24½	5.5	53.0	50.1	.963	4	.63	.32	87	.68
34	11-6	25	6.3	52.9	49.6	.963	4	.73	.36	90	.80
35	11-27	25¾	5.8	53.1	50.0	.963	4	.77	.39	85	.30
36	12-20	26½	6.0	53.5	50.3	.961	4	.94	.47	86	.79
	1955										
37	1-6	27	6.9	52.8	49.2	.961	4	.91	.47	87	.33
38	1-26	27¾	6.9	53.3	49.6	.963	4	.87	.44	88	.47
39	2-15	28½	6.8	53.5	49.8	.961	4	.98	.49	87	.69
40	3-17	29½	6.2	53.6	50.2	.960	3	.96	.48	87	.59
41	4-18	30½	6.8	53.6	49.9	.960	4	.82	.41	88	.74
42	5-10	31¼	6.1	54.0	50.7	.965	3	2.00	1.00	88	.30
43	5-31	32	5.9	53.2	50.1	.962	3	1.28	.64	87	.57
44	6-14	32½	5.5	52.3	49.4	.962	2	1.14	.57	87	.41
45 1/	7-1	33	5.1	52.5	49.8	.962	5	.6	.3	88	.55
46	10-28	36¾	5.3	51.6	48.0	.962	4	1.1	.6	87.2	.55
	1956										
47	1-19	39½	6.0	52.9	49.6	.963	6	.88	.44	88.4	.55
48	4-11	42¼	5.4	53.2	50.3	.960	3	.8	.4	86.2	.50
49	7-16	45½	4.9	52.8	50.2	.963	5	2.0	1.0	87.1	.50
50	10-4	48	4.9	52.6	50.0	.963	6	1.8	.9	86.9	.60
	1957										
51	1-11	51¼	5.7	52.8	49.8	.963	5	1.2	.6	86.5	.50
52	4-5	54	5.9	52.2	49.1	.963	6	1.2	.6	87.5	.50
53	7-9	57¼	5.0	52.5	49.8	.962	6	1.6	.8	87.1	.50
54	10-31	61	5.6	53.6	50.6	.963	7	2.0	1.0	85.7	.40
Average (by quarters)			5.6	53.4	50.2	.962	4.2	1.04	.52	86.9	.53

1/ First laboratory suspended testing. Same procedure used by second laboratory but different rounding of fractions.

Table [illegible].--Cracked and [illegible] castorbeans: Chemical analysis of samples of Connor variety (dryland) and of the oil ext[illegible]ted from them, the beans having been taken from storage during 1953-57

100 PERCENT CRACKED AND BROKEN BEANS

Sample number	Date sample was drawn	Months in storage	Castorbean analysis: Moisture clean sample	Castorbean analysis: Oil: Clean moisture free	Castorbean analysis: Oil: Whole sample	Castor oil analysis: Specific gravity	Color (Gardner)	Neutralization number	Free fatty acid (as oleic)	Iodine number	Unsaponifiable matter
	1953	Number	Percent	Percent	Percent	Percent	Number	Number	Percent	Number	Percent
1	2-20	5	5.7	58.9	55.6	0.961	3	0.67	0.34	87	0.49
2	3-26	6	5.4	60.6	57.3	.960	3	.83	.42	85	.43
3	4-14	6½	5.2	58.6	55.6	.963	2	.78	.39	86	.53
4	4-29	7	5.4	57.8	54.6	.964	3	.75	.35	86	.41
5	5-15	7½	5.3	59.2	56.1	.964	3	.88	.44	86	.59
6	5-29	8	4.8	58.4	55.6	.960	2	.30	.15	85	.51
7	6-15	8½	4.8	58.3	55.5	.961	3	.82	.41	87	.63
8	6-30	9	4.6	57.3	54.7	.959	2	.66	.33	87	.64
9	7-15	9½	4.5	59.2	56.6	.963	2	.87	.44	88	.69
10	7-31	10	4.6	59.2	56.4	.961	3	1.20	.60	88	.47
11	8-15	10½	4.7	58.7	55.9	.961	2	.72	.36	86	.31
12	8-31	11	4.8	58.8	56.0	.963	2	.94	.47	86	.52
13	9-15	11½	4.4	58.0	55.4	.961	2	.60	.30	87	.56
14	10-6	12	4.5	58.6	55.2	.958	2	.66	.33	85	.46
15	10-20	12½	4.3	59.4	56.8	.963	3	1.03	.52	82	.49
16	11-3	13	4.8	57.8	55.0	.962	3	.87	.44	83	.58
17	11-30	14	4.8	59.6	56.6	.956	2	1.18	.59	85	.53
18	12-31	15	5.0	58.2	55.2	.962	4	1.10	.55	87	.48
	1954										
19	1-25	16	5.2	59.0	56.0	.962	4	.76	.38	87	.37
20	2-23	17	4.9	58.6	55.7	.962	2	.88	.44	88	.48
21	3-29	18	5.1	59.7	56.7	.962	2	.90	.45	87	.55
22	4-15	18½	5.5	59.1	55.9	.962	3	.99	.50	88	.58
23	5-3	19	5.6	58.7	55.4	.962	2	.92	.46	87	.47
24	5-14	19½	5.5	59.2	55.9	.962	3	1.05	.53	87	.54
25	6-1	20	5.8	58.8	55.4	.962	3	1.09	.55	89	.55
26	6-14	20½	7.4	60.2	55.7	.961	2	1.17	.58	86	.41
27	7-12	21½	3.8	62.0	59.7	.964	4	2.46	1.24	86	.74
28	8-2	22	5.1	61.2	58.0	.964	5	2.22	1.12	87	.63
29	8-17	22½	4.4	58.0	55.5	.962	3	1.62	.81	84	.70
30	9-2	23	4.7	59.0	56.3	.961	4	2.16	1.09	87	.65
31	9-14	23½	4.5	59.7	57.1	.962	3	2.79	1.40	87	.56
32	10-4	24	5.4	58.8	55.7	.964	4	2.56	1.28	85	.48
33	10-18	24½	4.9	59.7	56.8	.962	4	2.08	1.05	85	.55
34	11-6	25	5.6	59.5	56.2	.963	4	1.90	.95	90	.57
35	11-27	25¾	5.2	57.9	54.9	.962	4	1.91	.96	87	.26
36	12-20	26½	5.5	59.0	55.8	.961	4	1.60	.80	87	.73
	1955										
37	1-6	27	6.3	57.3	53.7	.961	4	1.20	.62	87	.43
38	1-26	27¾	6.4	57.7	54.0	.963	4	1.36	.68	88	.63
39	2-15	28½	6.2	59.3	55.6	.960	4	1.47	.74	89	.51
40	3-17	29½	6.0	59.0	55.5	.960	3	1.34	.68	87	.74
41	4-18	30½	6.5	57.6	53.9	.961	4	1.48	.75	88	.77
42	5-10	31¼	5.8	55.5	52.8	.959	3	1.60	.80	86	.32
43	5-31	32	5.7	57.6	54.3	.960	3	1.75	.87	84	.67
44	6-14	32½	5.4	57.2	54.1	.962	3	1.74	.87	87	.36
45 1/	7-1	33	4.8	57.0	54.3	.963	6	4.8	2.4	87.8	.40
46	10-28	36¾	4.5	58.1	55.2	.962	4	4.0	2.0	86.7	.50
	1956										
47	1-19	39½	4.7	58.6	55.8	.962	10	6.6	3.3	88.8	.55
48	4-11	42¼	5.0	57.5	54.3	.961	4	4.0	2.0	87.5	.55
49	7-16	45½	4.7	54.8	51.9	.962	5	4.0	2.0	87.0	.50
50	10-4	48	4.4	57.6	54.8	.962	6	4.2	2.1	86.7	.60
	1957										
51	1-11	51¼	5.3	56.7	53.6	.962	5	4.2	2.1	87.8	.50
52	4-5	54	5.5	58.3	54.8	.963	7	4.8	2.4	87.6	.50
53	7-9	57¼	4.4	56.3	53.0	.962	6	7.8	3.9	87.7	.50
54	10-31	61	5.3	57.0	53.7	.962	6	10.0	5.0	87.1	.55
Average (by quarters)			5.1	58.0	54.9	.962	4.5	3.34	1.67	87.0	.52

1/ First laboratory suspended testing. Same procedure used by second laboratory but different rounding of fractions

Table 8.--Cracked and broken and whole castorbeans: Chemical analysis of samples of Connor variety (dryland) and of the oil extracted from them, the beans having been taken from storage during 1953-57

FIELD-RUN BEANS

Sample number	Date sample was drawn	Months in storage	Castorbean analysis: Moisture clean sample	Castorbean analysis: Oil: Clean moisture free	Castorbean analysis: Oil: Whole sample	Castor oil analysis: Specific gravity	Color (Gardner)	Neutralization number	Free fatty acid (as oleic)	Iodine number	Unsaponifiable matter
	1953	Number	Percent	Percent	Percent	Percent	Number	Number	Percent	Number	Percent
1	2-20	5	6.2	54.8	49.9	0.966	3	0.47	0.24	85	0.36
2	3-26	6	5.8	55.4	51.3	.964	3	.56	.28	84	.43
3	4-14	$6\frac{1}{2}$	5.6	54.8	50.6	.960	3	.49	.24	86	.61
4	4-29	7	5.9	54.6	49.8	.962	3	.90	.45	86	.36
5	5-15	$7\frac{1}{2}$	5.6	55.6	51.9	.961	3	.74	.37	82	.57
6	5-29	8	5.4	55.0	50.9	.963	2	.23	.12	87	.67
7	6-15	$8\frac{1}{2}$	4.9	54.7	52.1	.962	3	.54	.27	87	.51
8	6-30	9	5.0	54.0	51.3	.958	2	.74	.37	87	.66
9	7-15	$9\frac{1}{2}$	5.1	55.0	52.2	.961	2	.58	.29	86	.59
10	7-31	10	5.0	53.8	50.5	.961	3	.92	.46	88	.56
11	8-15	$10\frac{1}{2}$	5.7	54.3	50.2	.961	2	.76	.38	88	.38
12	8-31	11	5.1	54.0	51.2	.960	2	.56	.28	86	.27
13	9-15	$11\frac{1}{2}$	4.8	54.8	51.6	.965	2	.68	.34	87	.42
14	10-6	12	4.8	54.2	50.3	.962	2	.30	.15	84	.57
15	10-20	$12\frac{1}{2}$	4.8	54.2	50.4	.964	3	.68	.34	83	.44
16	11-3	13	5.2	53.7	49.4	.962	3	.58	.29	83	.61
17	11-30	14	5.8	54.0	50.6	.959	3	.72	.36	86	.41
18	12-31	15	5.4	54.2	51.3	.962	3	.76	.38	88	.38
	1954										
19	1-25	16	5.6	54.6	51.0	.963	3	.69	.35	87	.65
20	2-23	17	5.4	55.2	51.4	.962	2	.47	.24	88	.56
21	3-29	18	5.4	55.0	51.7	.962	2	.64	.32	87	.76
22	4-15	$18\frac{1}{2}$	5.9	54.0	49.8	.963	3	.62	.31	87	.73
23	5-3	19	6.0	55.4	51.4	.962	2	.46	.23	87	.45
24	5-14	$19\frac{1}{2}$	6.3	55.1	51.0	.963	3	.68	.34	88	.66
25	6-1	20	6.3	54.3	50.4	.962	3	.51	.26	88	.59
26	6-14	$20\frac{1}{2}$	5.9	54.6	50.5	.961	3	.68	.34	88	.55
27	7-12	$21\frac{1}{2}$	5.0	55.5	52.3	.961	3	.82	.41	87	.73
28	8-2	22	5.6	54.0	49.8	.961	4	.96	.48	87	.70
29	8-17	$22\frac{1}{2}$	5.2	54.2	51.0	.964	3	.96	.48	87	.56
30	9-2	23	4.9	53.8	49.8	.961	3	1.15	.57	87	.54
31	9-14	$23\frac{1}{2}$	4.8	53.8	50.3	.961	3	1.50	.76	89	.57
32	10-4	24	5.5	55.0	51.1	.963	4	1.30	.65	85	.39
33	10-18	$24\frac{1}{2}$	5.8	54.5	50.8	.962	4	1.01	.51	88	.58
34	11-6	25	6.1	54.5	50.5	.963	4	.90	.45	88	.50
35	11-27	$25\frac{3}{4}$	5.7	53.3	48.8	.961	4	1.02	.52	86	.46
36	12-20	$26\frac{1}{2}$	5.9	53.9	49.9	.962	4	.97	.49	87	.83
	1955										
37	1-6	27	6.9	53.3	48.6	.961	4	1.22	.62	87	.47
38	1-26	$27\frac{3}{4}$	6.7	52.5	48.2	.962	4	.80	.40	88	.63
39	2-15	$28\frac{1}{2}$	6.6	54.6	50.1	.962	4	.92	.46	88	.46
40	3-17	$29\frac{1}{2}$	6.4	52.0	48.0	.963	4	.95	.48	87	.61
41	4-18	$30\frac{1}{2}$	6.7	54.4	48.9	.962	4	.91	.46	89	.46
42	5-10	$31\frac{1}{4}$	6.2	54.5	50.3	.959	3	1.48	.74	87	.26
43	5-31	32	6.2	55.3	51.3	.960	3	2.10	1.05	84	.61
44	6-14	$32\frac{1}{2}$	5.6	53.5	49.2	.961	3	1.83	.92	87	.65
45 1/	7-1	33	5.0	53.3	49.9	.962	4	.8	.4	87.7	.45
46	10-28	$36\frac{3}{4}$	5.3	53.2	49.4	.961	4	1.5	.8	86.6	.45
	1956										
47	1-19	$39\frac{1}{2}$	6.0	53.1	49.0	.962	6	3.5	1.8	87.4	.60
48	4-11	$42\frac{1}{4}$	5.4	53.5	49.3	.961	4	1.6	.8	87.6	.55
49	7-16	$45\frac{1}{2}$	5.0	52.7	48.2	.963	8	2.6	1.3	86.5	.50
50	10-4	48	4.8	52.4	48.5	.962	6	1.8	.9	86.1	.60
	1957										
51	1-11	$51\frac{1}{4}$	5.6	53.7	49.6	.963	5	2.0	1.0	88.0	.55
52	4-5	54	5.9	53.7	48.5	.963	7	2.6	1.3	88.0	.50
53	7-9	$57\frac{1}{4}$	4.9	52.8	48.5	.963	6	3.4	1.7	87.7	.50
54	10-31	61	5.9	53.1	48.9	.963	7	4.0	2.0	86.8	.50
Average (by quarters)			5.6	53.8	49.7	.962	4.4	1.61	.80	87.0	.53

1/ First laboratory suspended testing. Same procedure used by second laboratory but different rounding of fractions.

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